DOCUMENT RESUME

ED 456 222 CE 082 158

AUTHOR Joerschke, John D.; Eichhorn, Lane

TITLE Diesel Technology: Introduction. Teacher Edition [and] Student Edition. Second Edition.

INSTITUTION Multistate Academic and Vocational Curriculum Consortium, Stillwater, OK.

PUB DATE 2001-00-00

NOTE 908p.; For revision of 1997 edition, see ED 417 277. Edited by Jane Huston.

AVAILABLE FROM Multistate Academic and Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, OK 74074-4364 (Teacher edition: order no. 203101, $114.50; Student edition: order no. 203102, $57.50). Tel: 800-654-3988 (Toll Free); e-mail: mavccweb@okcareertech.org, Web site: http://www.mavcc.org.

PUB TYPE Guides - Classroom - Learner (051) -- Guides - Classroom - Teacher (052)

EDRS PRICE EDRS Price MF06 Plus Postage. PC Not Available from EDRS.

DESCRIPTORS *Auto Mechanics; Competency Based Education; Curriculum Guides; *Diesel Engines; Hydraulics; Instructional Materials; Job Analysis; Learning Activities; *Metal Working; Postsecondary Education; Power Technology; Secondary Education; Teaching Guides; *Technology Education; Tests; Units of Study; *Welding

IDENTIFIERS Crosswalks (Linking)

ABSTRACT

This complete teacher edition of a diesel technology course consists of introductory pages, teacher pages, and the student edition. The introductory pages provide these tools: training and competency profile; National Automotive Technicians Education Foundation Crosswalk; instructional/task analysis; basic skills icons and classifications; basic skills matrix; and tools, equipment, and materials list. The teacher pages consist of some or all of these components for each unit: suggested activities; answers to assignment sheets; written test with answer key; learning activities sheet(s); teacher supplements; and transparency masters. The student edition provides some or all of these components for each unit: objective sheet; information sheet; student supplements; assignment sheets; and job sheets. Twelve units are grouped into three sections. Section A: Workplace Tools has these five units: overview of diesel-powered vehicles, basic tools and equipment, reference materials, measuring instruments, and shop operation. Section B: Common Materials has these four units: mechanical fasteners; lines, fittings, and couplings; seals and bearings; and fluids and lubricants. Section C has three units: basic electrical principles, basic hydraulic principles, and basic welding and cutting. (YLB)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 456 222

Diesel Technology: Introduction
Teacher Edition [and] Student Edition
Second Edition

John D. Joerschke
Lane Eichhorn

PERMISSION TO REPRODUCE AND
DISSEMINATE THIS MATERIAL IN
MICROFICHE ONLY HAS BEEN GRANTED BY

A. Pratt

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)
2B

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

● Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

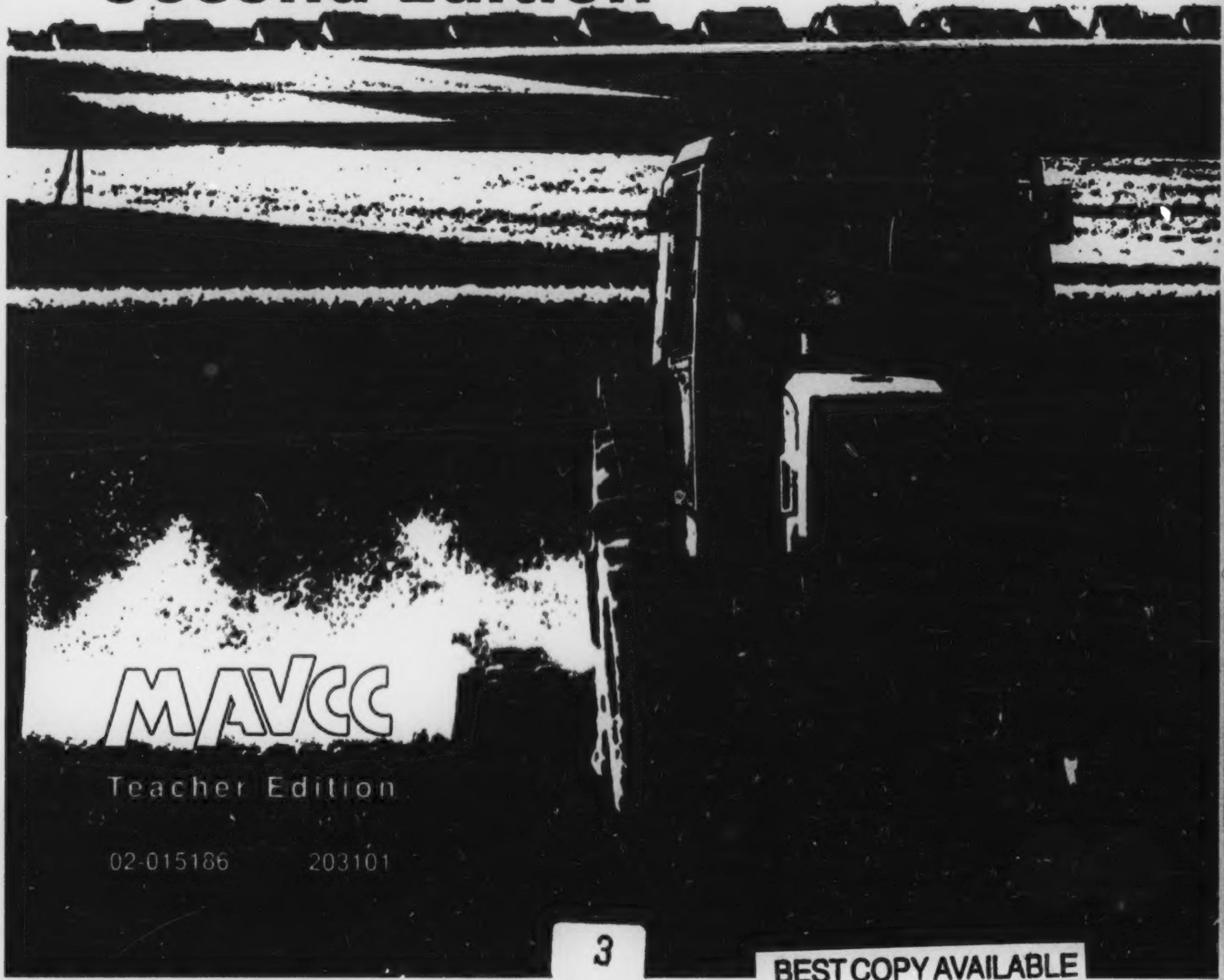
CE082158

BEST COPY AVAILABLE

Diesel Technology

Introduction

Second Edition



MAVCC

Teacher Edition

02-015186 203101

BEST COPY AVAILABLE

Diesel Technology: Introduction

Second Edition

Teacher Edition

Written by

John D. Joerschke
Lane Eichhorn

Edited by

Jane Huston

Developed by

The Multistate Academic and Vocational Curriculum Consortium, Inc.

Board of Directors

Mervin Birdwell, Louisiana, Chair
Dana Tannehill, Missouri, Vice Chair
Kimberly Sadler, Oklahoma, Parliamentarian
John Davidson, Arkansas
Shirley Gantt, Georgia
Jim Fliehler, Iowa
Ben Clay, Kansas
David Closky, Pennsylvania
Larry Nelson, South Dakota
Lynne Cohen, Tennessee
Bennie Walker, Texas

Clark R. Harris, Executive Director

02-015186

203101

©2001 by the Multistate Academic and Vocational Curriculum Consortium, Inc.

All rights reserved. No part of this book may be reproduced in any form or by any means without written permission from the publisher unless otherwise specified.

Printed in the United States of America by the
Oklahoma Department of Career and Technology Education
Stillwater, OK 74074-4364

For more information, contact the
Multistate Academic and Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

E-mail: mavcc@mavcc.com
Internet: http://www.mavcc.org
Phone: (800)654-3988 or (405)743-5578

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

Table of Contents

Introductory Pages

Foreword v
Acknowledgments vii
Use of this publication ix
Training and competency profile xvii
NATEF crosswalk xxi
Instructional/task analysis xxiii
Basic skills icons and classifications xxxiii
Basic skills matrix xxxvii
Tools, equipment, and materials list lix

Units of Instruction

Section A: Workplace Tools

Unit 1-A: Overview of Diesel-Powered Vehicles

Unit 2-A: Basic Tools and Equipment

Unit 3-A: Reference Materials

Unit 4-A: Measuring Instruments

Unit 5-A: Shop Operation

Section B: Common Materials

Unit 1-B: Mechanical Fasteners

Unit 2-B: Lines, Fittings, and Couplings

Unit 3-B: Seals and Bearings

Unit 4-B: Fluids and Lubricants

Section C: Basic Related Principles

Unit 1-C: Basic Electrical Principles

Unit 2-C: Basic Hydraulic Principles

Unit 3-C: Basic Welding and Cutting

Foreword

When MAVCC began the process for revising its diesel mechanics series, we wanted to develop a set of instructional materials that would provide students with the cognitive (knowing), psychomotor (doing), and affective (attitude) skills necessary to be successful in the diesel trade and that would address the emerging technology in the field. With the help of extremely qualified teachers, industry representatives, and writers, our new diesel technology series offers secondary and postsecondary students an excellent opportunity for learning required skills in the diesel industry.

The series aligns with the medium/heavy duty truck task list developed by the National Automotive Technicians Education Foundation (NATEF) and used by the National Institute for Automotive Service Excellence (ASE) in the certification of medium/heavy duty truck technicians. Our series addresses all but one of the ASE certification areas, gasoline engines, and includes the following publications: *Introduction, Safety Skills, Workplace Skills, Brakes, Steering and Suspension, Engines, Electrical and Electronic Systems, Air Conditioning, Drive Trains*, and *Hydraulics.* Each publication will include a matrix showing where the NATEF tasks are being taught.

The new publications will also reflect those tasks identified by MAVCC's technical committee which were not covered in the NATEF task list, especially those dealing with the maintenance and repair of diesel-powered heavy equipment and agriculture equipment.

These instructional materials are designed for student use and to assist teachers in organizing and improving instruction. Their design is based on the curriculum alignment concept of first stating the objectives (objective sheet), developing instructional strategies for teaching to those objectives (information, assignment, and job sheets), and assessing to those same objectives (criterion-referenced evaluation instruments).

As with all MAVCC publications, teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers. Teachers are also encouraged to develop strategies for motivating their students.

Foreword

A matrix which classifies and defines each of the academic and workplace skills and competencies has been included in the teacher edition and reflects key elements from *What Work Requires of Schools: A SCANS Report fof America 2000*, a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want*, a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources. These tools have been provided in an effort to help educators identify and document where basic academic and workplace skills are being taught. By reinforcing these skills, the teacher should assist students in improving their employability skills.

As you use these instructional materials, we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please call or write us.

Mervin Birdwell, Chair
Board of Directors
Multistate Academic and
Vocational Curriculum
Consortium

Clark R. Harris
Executive Director
Multistate Academic and
Vocational Curriculum
Consortium

Acknowledgments

Appreciation is extended to the many individuals who contributed their time and talent to the development of *Diesel Technology: Introduction.*

The content of this publication was planned by the following members of the MAVCC diesel revision committee:

Lane Eichhorn
Parkland College
Champaign, IL

Danny Fisher
Pulaski Technical College
North Little Rock, AR

David Kennedy
T.H. Harris Technical Institute
Opelousas, LA

Orville Manuel
Oklahoma Department of Career
and Technology Education
Stillwater, OK

Roger Miller
Salina Area Vocational School
Salina, KS

Terry Scarberry
Gordon Cooper Technology Center
Shawnee, OK

Carl Tesch
Lake Area Technical Institute
Watertown, SD

Larry Wright
DARR Equipment
Dallas, TX

Richard Wright
Vocational-Technical Division of the
Arkansas Department of Education
Little Rock, AR

Appreciation is also extended to the original writers of MAVCC's *Diesel Fundamentals* (©1988). Thank you Elton Clark, Joe Mathis, and Tom Sprinkle.

Thanks are also given to Jane Huston and Sue Jones for their assistance with committee facilitation.

Special appreciation is extended to Cheryl Barr, instructional development specialist, for her assistance with preparing tests and obtaining supplemental resources, and to Rick Lomenick, electronic publishing technician, for his assistance in scanning artwork and formatting units of instruction for this second edition.

Appreciation is also extended to the Graphics Division of the Oklahoma Department of Career and Technology Education for the original artwork and printing of this text.

9

Use of This Publication

Diesel Technology: Introduction is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the diesel advisory committee, comprised of business/industry representatives and teachers. Competencies in the diesel technology series align with the medium/heavy duty truck task list developed by the National Automotive Technicians Education Foundation (NATEF) and used by the National Institute for Automotive Service Excellence (ASE) in the certification of medium/heavy duty truck technicians.

Teacher Edition

The complete teacher edition consists of introductory pages, teacher pages, and the student edition. The introductory pages, teacher pages, and student edition also are loose-leaf and three-hole punched. The teacher edition is divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit is individually numbered beginning with a T for teacher, followed by the unit number and page number.

Example:

Page 17 of Unit 3 in the teacher pages are represented as T 3–17.

MAVCC *Diesel Technology: Introduction* T 3—17

Page 1 of Unit 5 in the teacher pages are represented as T 5–1.

MAVCC—*Diesel Technology: Introduction* T 5-1

Pages in the student edition are numbered beginning with the unit number, followed by the page number.

Example:

Page 7 of Unit 5 in the student edition is represented as Page 5–7.

MAVCC *Diesel Technology: Introduction* Page 5—7

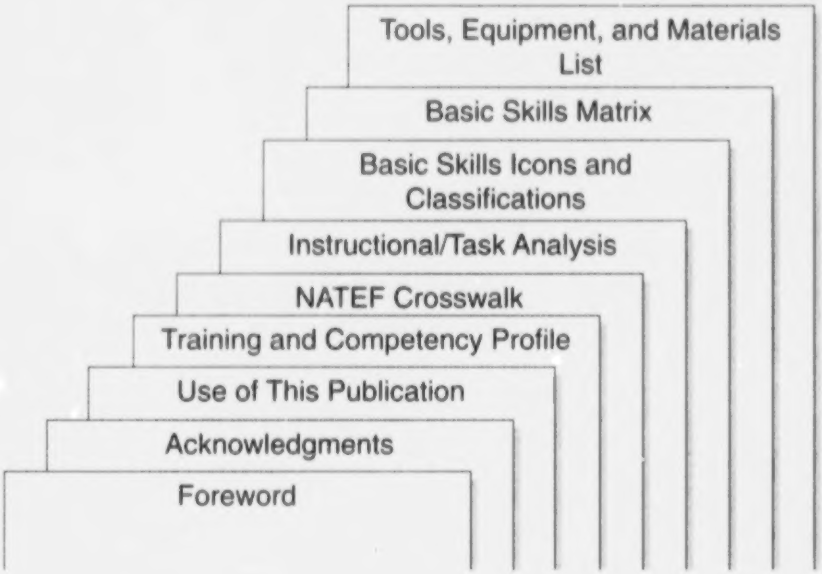
Use of This Publication

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages


Tools, Equipment, and Materials List
Basic Skills Matrix
Basic Skills Icons and Classifications
Instructional/Task Analysis
NATEF Crosswalk
Training and Competency Profile
Use of This Publication
Acknowledgments
Foreword

Use of This Publication

In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

- ☐ **Training and Competency Profile.** This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.

- ☐ **NATEF Crosswalk.** This chart identifies the National Automotive Technicians Education Foundation, Inc., (NATEF) tasks covered in this publication and lists specifically where these tasks are located by unit number and assignment or job sheet number. This is provided for programs and students preparing for ASE certification.

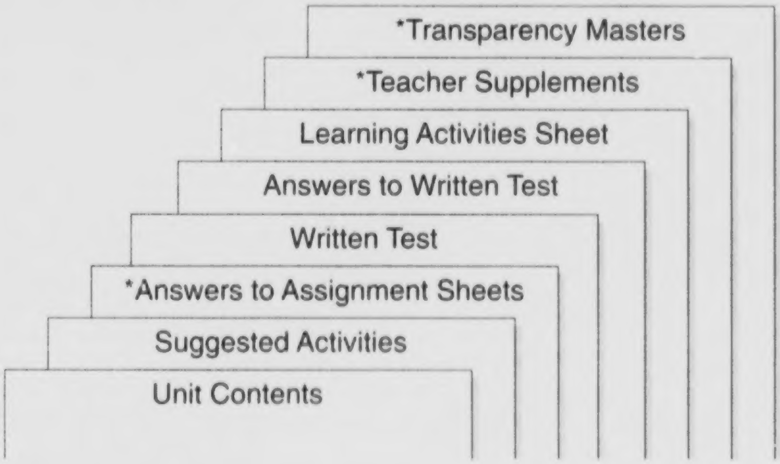
- ☐ **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.

- ☐ **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each assignment sheet and job sheet.

- ☐ **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.

- ☐ **Tools, Equipment, and Materials List.** This page provides a comprehensive list of those items needed to successfully complete the assignment sheets and/or job sheets; assists administrator/teacher in determining program costs.

Teacher Pages


*Transparency Masters
*Teacher Supplements
Learning Activities Sheet
Answers to Written Test
Written Test
*Answers to Assignment Sheets
Suggested Activities
Unit Contents

*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

- ☐ **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

  Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

- ☐ **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

- ☐ **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

☐ **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

☐ **Learning Activities Sheet.** This component provides a model for teachers to use in implementing a self-paced or individualized program, and guides the student through the required components in the student edition (objective sheet, information sheet, student supplements, assignment sheets, and job sheets). The teacher should modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student. Final copies should be distributed for student use.

The following icons will be used on the learning activities sheet to denote steps that require additional resources:

📖 Read a book, magazine, or journal article

💻 Use a CBT program or other software application

WWW Access a site on the World Wide Web

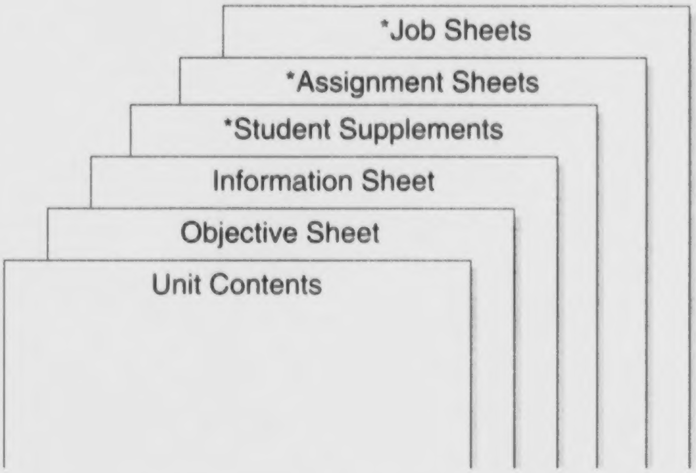
🖥 Look at PowerPoint® or other computer presentation

📼 Watch a videotape

☐ **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

☐ **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Edition



*Designates components that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

☐ **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

☐ **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

☐ **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

☐ **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. Criteria are provided to evaluate student performance objectively.

☐ **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, or E-mail us at mavcc@mavcc.com.

Training and Competency Profile

Student Information

Program ______ Instructor ______

Name ______ Soc. Sec. No. ______

Address ______ Phone ______

Grade ______ School ______

Allergies/Disabilities that might require special accommodation for training (please specify)

______

In case of emergency, contact ______ Phone ______

Record of Enrollment

Date of Enrollment ___-___-___ Total Class Hours ______ Total Hours Absent ______

Date of Withdrawal ___-___-___ Total On-the-Job Training Hours ______ Total Hours Tardy ______

Date of Completion ___-___-___ Total Lab Hours ______

On-the-Job Training/Work Experience

Place of Employment ______ Address ______

Supervisor's Name ______ Phone ______

Duration of Employment ______ Job Title ______

Job Responsibilities ______

Place of Employment ______ Address ______

Supervisor's Name ______ Phone ______

Duration of Employment ______ Job Title ______

Job Responsibilities ______

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Rating Scale: Option A

4	Skilled—Can perform job with no additional training
3	Moderately Skilled—Has performed job during training program; limited additional training may be required.
2	Limited Skill—Has performed job during training program; additional training is required to develop skill.
1	Unskilled—Is familiar with process, but is unable to perform job.
0	No Exposure—No information or practice provided during training program, complete training required.
NA	Non-applicable.

Rating Scale: Option B

Yes—Can perform with no additional training
No—Is unable to perform satisfactorily

SECTION A: WORKPLACE TOOLS

Unit 1-A: Overview of Diesel-Powered Vehicles

______ 1. Identify features for assigned on-road vehicle.
______ 2. Identify features for assigned off-road vehicle.
______ 3. ______________________________

______ Written Test Score

Unit 2-A: Basic Tools and Equipment

______ 1. Use tool catalogs to determine the cost of a quality hand tool set.
______ 2. Dress a grinding wheel.
______ 3. Sharpen a twist drill bit.
______ 4. Drill holes with a drill press.
______ 5. Sharpen a cold chisel.
______ 6. Use a file.
______ 7. ______________________________

______ Written Test Score

Unit 3-A: Reference Materials

______ 1. Interpret drawings used in diesel equipment reference materials.
______ 2. Interpret graphs used in diesel equipment reference materials.
______ 3. Interpret diagrams used in diesel equipment reference materials.
______ 4. Interpret tables used in diesel equipment reference questions.
______ 5. Use reference materials to answer specfic questions.
______ 6. ______________________________

______ Written Test Score

Unit 4-A: Measuring Instruments

______ 1. Read U.S. customary and metric rules.
______ 2. Draw lines to specified lengths.
______ 3. Measure lines using a steel rule.
______ 4. Measure lines on objects.
______ 5. Measure circle diameters.
______ 6. Read standard and metric micrometers.
______ 7. Use a dial caliper.
______ 8. Use outside micrometer.
______ 9. Use inside micrometer.
______ 10. Use telescoping gauges.
______ 11. Use a dial indicator.
______ 12. Check a torque wrench for accuracy.
______ 13. Use a small hole gauge to measure valve guide diameter.
______ 14. Use a cylinder bore gauge.
______ 15. ______________________________

______ Written Test Score

Unit 5-A: Shop Operation

______ 1. Complete a job ticket.
______ 2. Use a computer system to obtain parts information.
______ 3. ______________________________

______ Written Test Score

Training and Competency Profile

SECTION B: COMMON MATERIALS

Unit 1-B: Mechanical Fasteners

______ 1. Measure U.S. customary bolts and threads.
______ 2. Measure metric bolts and threads.
______ 3. Match bolts with the correct size wrenches.
______ 4. Extract a broken bolt, stud, or screw.
______ 5. Restore external threads.
______ 6. Cut and restore internal threads.
______ 7. Install a thread insert.
______ 8. ______________________________

______ Written Test Score

Unit 2-B: Lines, Fittings, and Couplings

______ 1. Describe characteristics of pipe, tubing, and hose.
______ 2. Identify fittings and threads.
______ 3. Replace a skive hose end.
______ 4. Replace a no skive hose end.
______ 5. ______________________________

______ Written Test Score

Unit 3-B: Seals and Bearings

______ 1. Install a radial lip seal.
______ 2. Remove and install an engine oil seal and wear sleeve.
______ 3. Install a packing.
______ 4. Replace a formed gasket.
______ 5. Replace a formed-in-place gasket.
______ 6. Remove and install a camshaft friction bearing.
______ 7. Remove and install an antifriction bearing.
______ 8. Clean and pack an antifriction bearing.
______ 9. ______________________________

______ Written Test Score

Unit 4-B: Fluids and Lubricants

______ 1. Test for combustion leakage into a cooling system.
______ 2. Test for air in a cooling system.
______ 3. Clean a cooling system.
______ 4. Change oil and oil filter.
______ 5. ______________________________

______ Written Test Score

SECTION C: BASIC RELATED PRINCIPLES

Unit 1-C: Basic Electrical Principles

______ 1. Solve problems using Ohm's law.
______ 2. Interpret electrical values from multimeter settings.
______ 3. Interpret wiring diagrams.
______ 4. Measure current, voltage, and resistance with a multimeter.
______ 5. Test and replace light bulbs and test sockets.
______ 6. Tin a soldering iron or gun.
______ 7. Solder-splice electrical wiring.
______ 8. Install terminals and connectors.
______ 9. Test charge a conventional (non-sealed) battery.
______ 10. Test charge a sealed battery.
______ 11. Slow charge a battery.
______ 12. Perform a battery load test.
______ 13. Perform a high-rate battery charge test.
______ 14. Emergency jump-start a vehicle.
______ 15. ______________________________

______ Written Test Score

Unit 2-C: Basic Hydraulic Principles

______ 1. Draw a block diagram of a simple hydraulic system.
______ 2. Perform general maintenance procedures on a hydraulic system.
______ 3. Change hydraulic fluid and filter.
______ 4. ______________________________

______ Written Test Score

Unit 3-C: Basic Welding and Cutting

______ 1. Start, stop, and restart a bead.
______ 2. Construct a pad weld.
______ 3. Construct a butt weld.
______ 4. Construct a lap-joint fillet weld in the flat position.
______ 5. Construct a T-joint fillet weld in the flat position.
______ 6. Set up equipment for oxyacetylene welding/cutting.
______ 7. Turn on, light, adjust, and turn off oxyacetylene welding equipment.
______ 8. Braze weld a lap joint.
______ 9. Cut mild steel at a 90-degree angle, stop, and restart the cut.
______ 10. Cut round stock.
______ 11. ______________________________

______ Written Test Score

Permission to duplicate this profile is granted.

NATEF Crosswalk

The following NATEF tasks (rev. 1998) are covered in this publication. The first column identifies the NATEF task by name and number. The second column identifies the exact location by unit number and job sheet number in this MAVCC publication.

NATEF Tasks	MAVCC Tasks
II. Diesel Engines D. Lubrication Systems Diagnosis and Repair	
II. D. 7.—Perform oil and filter change	Unit 4–B, Job Sheet 4—Change oil and oil filter
II. Diesel Engines E. Cooling System Diagnosis and Repair	
II. E. 6.—Recover, flush, and refill with recommended coolant/additive package; bleed cooling system	Unit 4–B, Job Sheet 3—Clean a cooling system
VI. Electrical/Electronic Systems B. Battery Diagnosis and Repair	
VI. B. 1.—Perform battery hydrometer test; determine specific gravity of each cell.	Unit 1–C, Job Sheet 6—Test charge a conventional (non-sealed) battery.
VI. B. 2.—Perform battery load test; determine needed service.	Unit 1–C, Job Sheet 9—Perform a battery load test. Unit 1–C, Job Sheet 10—Perform a high-rate battery charge test.
VI. B. 3.—Determine battery state of charge using an open circuit voltage tester.	Unit 1–C, Job Sheet 6—Test charge a conventional battery. Unit 1–C, Job Sheet 7—Test charge a sealed battery. Unit 1–C, Job Sheet 9—Perform a battery load test. Unit 1–C, Job Sheet 10—Perform a high-rate battery charge test.
VI. B. 4.—Inspect, clean, and service battery; replace as needed.	Unit 1–C, Job Sheet 6—Test charge a conventional battery. Unit 1–C, Job Sheet 7—Test charge a sealed battery.
VI. B. 5.—Inspect and clean battery boxes, mounts, and hold downs, repair or replace as needed.	Unit 1–C, Job Sheet 6—Test charge a conventional battery. Unit 1–C, Job Sheet 7—Test charge a sealed battery.
VI. B. 6.—Charge battery using slow or fast charge methods as appropriate.	Unit 1–C, Job Sheet 8—Slow charge a battery.

NATEF Tasks	MAVCC Tasks
VI. B. 7. Inspect, test, and clean battery cables and connectors; repair or replace as needed.	Unit 1–C, Job Sheet 6—Test charge a conventional battery. Unit 1–C, Job Sheet 7—Test charge a sealed battery.
VI. B. 8. Jump start a vehicle using jumper cables and a booster battery using proper safety procedures.	Unit 1–C, Job Sheet 11—Emergency jump-start a vehicle.

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

SECTION A: WORKPLACE TOOLS

Unit 1–A: Overview of Diesel-Powered Vehicles

1. Terms and definitions
2. Common diesel-powered vehicles
3. Reasons for new vehicle designs
4. Major functional areas of vehicles
5. Major vehicle systems
6. Truck weights
7. Gross vehicle weight ranges for on-road truck weight classifications
8. Axle and drive wheel configurations
9. Basic truck cab designs
10. Common types of trailers
11. Parts of a trailer
12. Types of tractor-trailer combinations
13. Truck dimensions
14. Agricultural tractor dimensions
15. Terms related to tractors
16. Characteristics of final drives
17. Characteristics of power takeoffs
18. Deck machinery
19. Identify features for assigned on-road vehicle
20. Identify features for assigned off-road vehicle

Unit 2–A: Basic Tools and Equipment

1. Terms and definitions
2. Types of cutting tools
3. Types of hammers
4. Types of pliers
5. Types of pullers
6. Types of screwdrivers

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2–A: Basic Tools and Equipment (continued)

7. Types of wrenches
8. Parts of a socket wrench set
9. Basic power tools
10. Basic shop equipment
11. Other general shop tools and equipment
12. Correct and incorrect methods of using and maintaining basic hand tools
13. Safety guidelines for using power tools and equipment

14. Use tool catalogs to determine the cost of a quality hand tool set
15. Dress a grinding wheel
16. Sharpen a twist drill bit
17. Drill holes with a drill press
18. Sharpen a cold chisel
19. Use a file

Unit 3–A: Reference Materials

1. Terms and definitions
2. Types of reference materials
3. Types of illustrations used in reference materials
4. Types of graphs used in reference materials
5. Types of diagrams used in reference materials
6. Parts of a reference table
7. Types of tables used in reference materials

8. Interpret drawings used in diesel equipment reference materials
9. Interpret graphs used in diesel equipment reference materials
10. Interpret diagrams used in diesel equipment reference materials
11. Interpret tables used in diesel equipment reference materials
12. Use reference materials to answer specific questions

Unit 4–A: Measuring Instruments

1. Terms and definitions
2. Basic measurement systems
3. Types of rules used by diesel technicians
4. Basic units of measurement found on rules
5. Guidelines for using rules
6. Types of calipers
7. Parts of a dial caliper
8. Guidelines for care of calipers
9. Types of micrometers
10. Parts of an outside micrometer
11. How to select the proper size outside micrometer

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 4–A: Measuring Instruments (continued)

12. Methods for checking accuracy of an outside micrometer
13. Parts of an inside micrometer
14. Accessories for an inside micrometer
15. Uses of an inside micrometer
16. Methods for checking accuracy of an inside micrometer
17. Rules for use and care of micrometers
18. Types of gauges and their uses
19. Parts of a dial indicator set
20. Types of torque wrenches
21. Use and care of torque wrenches
22. Types of feeler gauges
23. Instruments used to measure angles
24. Read U.S. customary and metric rules
25. Draw lines to specified lengths
26. Measure lines using a steel rule
27. Measure lines on objects
28. Measure circle diameters
29. Read standard and metric micrometers
30. Use a dial caliper
31. Use outside micrometer
32. Use inside micrometer
33. Use telescoping gauges
34. Use a dial indicator
35. Check a torque wrench for accuracy
36. Use a small hole gauge to measure valve guide diameter
37. Use a cylinder bore gauge

Unit 5–A: Shop Operation

1. Terms and definitions
2. Basic categories of shop operation
3. Purposes of parts management
4. Guidelines for maintaining good inventory control
5. Publications used for identifying part numbers
6. Parts of a job ticket
7. Reasons for using standard time rate tables
8. Reasons for using employee time cards
9. Payroll record keeping
10. Complete a job ticket
11. Use a computer system to obtain parts information

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

SECTION B: COMMON MATERIALS

Unit 1–B: Mechanical Fasteners

Related Information: What the Student Should Know

1. Terms and definitions
2. Qualities of satisfactory fasteners
3. Typical threaded fasteners
4. Characteristics of threaded fasteners
5. Typical bolt head designs
6. Typical machine screw head designs
7. Typical nuts
8. Typical nuts and bolts with locking or self-locking features
9. Devices used for securing threaded fasteners
10. Typical nonthreaded fasteners
11. Tools used to remove seized threaded fasteners
12. Anti-seize compounds
13. Parts of a tap and die set
14. Tools used to restore or replace threads on threaded fasteners
15. Types of taps

Application: What the Student Should Be Able to Do

16. Measure U.S. customary bolts and threads
17. Measure metric bolts and threads
18. Match bolts with the correct size wrenches
19. Extract a broken bolt, stud, or screw
20. Restore external threads
21. Cut and restore internal theads
22. Install a thread insert

Unit 2–B: Lines, Fittings, and Couplings

1. Terms and definitions
2. Applications that use lines, fittings, and couplings
3. Hazards of incorrect or improperly installed lines, fittings, and couplings
4. Rules for safe use and installation of lines, fittings, and couplings
5. Characteristics of pipe
6. Characteristics of metal tubing
7. Characteristics of nylon and plastic tubing
8. Characteristics of flexible hose
9. Types of fittings commonly used with pipe

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2–B: Lines, Fittings, and Couplings (continued)

10. Types of fittings commonly used with tubing
11. Types of hose ends
12. Common configurations of hose ends
13. Common valves
14. Types of accessories
15. Installation of pipe or tubing
16. Installation of hose
17. Describe characteristics of pipe, tubing, and hose
18. Identify fittings and threads
19. Replace a skive hose end
20. Replace a no skive hose end

Unit 3–B: Seals and Bearings

1. Terms and definitions
2. Purposes of seals
3. Basic categories of seals
4. Common seals
5. Parts of a lip seal
6. Common materials for seals
7. Types of packings
8. Causes of sealing failure
9. Guidelines for installing seals
10. Types of gaskets
11. Common gasket materials
12. Guidelines for installing gaskets
13. Functions of bearings
14. Basic categories of bearings
15. Major types of bearings
16. Parts of an antifriction bearing
17. Load forces of bearings
18. Conditions that determine load-carrying capacity of bearings
19. Common materials used for bearings
20. Reasons for bearing failures
21. Bearing maintenance procedures
22. Items to look for when inspecting bearings
23. Install a radial lip seal
24. Remove and install an engine oil seal and wear sleeve
25. Install a packing
26. Replace a formed gasket
27. Replace a formed-in-place gasket
28. Remove and install a camshaft friction bearing
29. Remove and install an antifriction bearing
30. Clean and pack an antifriction bearing

Instructional/Task Analysis

Unit 4–B: Fluids and Lubricants

Related Information: What the Student Should Know

1. Terms and definitions
2. Fluid safety rules
3. Basic components of fluid systems
4. Common types of filters
5. Comon additives to fluids
6. Effects of contaminants to fluid systems
7. Practices for ensuring fluid system cleanliness
8. Applications of fluid systems on diesel/heavy duty equipment
9. Flow of fuel through the fuel system
10. Grades of diesel fuel used on diesel/heavy duty equipment
11. Alternative fuels that may be used on diesel/heavy duty equipment
12. Purpose of a cooling system
13. Effects of a malfunctioning cooling system
14. Parts of a liquid cooling system
15. Liquid cooling systems in diesel/heavy duty equipment
16. Characteristics of a good antifreeze
17. Importance of engine lubrication
18. Functions of engine oil
19. Parts of the engine lubrication system
20. Characteristics of a good engine oil
21. Viscosity
22. API classification system
23. Oil maintenance procedures
24. Fluids/oils for transmissions and gearboxes
25. Fluids for power steering
26. Locations of filters in hydraulic systems
27. Types of filter circuits in hydraulic systems
28. Chassis lubrication systems
29. Chassis grease
30. Maintenance of chassis lubrication systems
31. Batteries

Application: What the Student Should Be Able to Do

32. Test for combustion leakage into a cooling system
33. Test for air in a cooling system
34. Clean a cooling system
35. Change oil and oil filter

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

SECTION C: BASIC RELATED PRINCIPLES

Unit 1–C: Basic Electrical Principles

1. Terms and definitions
2. Electron theory of electricity
3. Characteristics of electricity
4. Basic electrical units
5. Ohm's law and Watt's law
6. Equipment used to measure electrical characteristics
7. Components of a basic electrical circuit
8. Types of electrical current flow
9. Types of basic electrical circuits
10. Electron flow through a single wire circuit
11. Circuit protection devices
12. Types of electrical circuit problems
13. Schematic symbols used on wiring diagrams
14. How to read wiring diagrams
15. Steps in soldering
16. Guidelines for soldering
17. Electrical terminals and connectors
18. Battery service tools
19. Guidelines for servicing batteries
20. Safety procedures to follow when working on batteries.
21. Solve problems using Ohm's law
22. Interpret electrical values from multimeter settings
23. Interpret wiring diagrams
24. Measure current, voltage, and resistance with a multimeter
25. Test and replace light bulbs and test sockets
26. Tin a soldering iron or gun
27. Solder-splice electrical wiring
28. Install terminals and connectors
29. Test charge a conventional (non-sealed) battery
30. Test charge a sealed battery
31. Slow charge a battery
32. Perform a battery load test
33. Perform a high-rate battery charge test
34. Emergency jump-start a vehicle

Unit 2–C: Basic Hydraulic Principles

1. Terms and definitions
2. Systems that use hydraulics in diesel technology
3. Advantages and disadvantages of hydraulic systems
4. Components of a basic hydraulic system
5. Steps in the basic operation of a hydraulic system

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2–C: Basic Hydraulic Principles (continued)

6. Basic hydraulic principles
7. Calculating pressure
8. Functions of hydraulic fluid
9. Types of reservoirs
10. Parts of a reservoir
11. Causes of damage to hydraulic systems
12. Common problems in hydraulic systems
13. Reasons for performing preventive maintenance on hydraulic systems
14. Steps for general maintenance of a hydraulic system
15. Steps in keeping hydraulic systems clean
16. Safety hazards and safety practices when working with hydraulic systems
17. Draw a block diagram of a simple hydraulic system
18. Perform general maintenance procedures on a hydraulic system
19. Change hydraulic fluid and filter

Unit 3–C: Basic Welding and Cutting

1. Terms and definitions
2. Safety precautions to follow when welding
3. Welding materials
4. Basic arc welding circuit
5. Parts of the arc welding process
6. Types of arc welding machines
7. Polarity
8. Effects of raising and lowering welding machine amperes
9. Common types of arc welding electrodes
10. Common diameter sizes of arc welding electrodes
11. Meanings of AWS electrode classification number
12. Factors to consider when selecting electrodes
13. Purposes of eletrode flux
14. Types of welds

Unit 3–C: Basic Welding and Cutting (continued)

Related Information: What the Student Should Know

15. Types of weld joints
16. Characteristics of good welds
17. Reasons for poor welds
18. Methods of striking an arc
19. Characteristics of proper arc length
20. Types of electrode motions
21. Positions used in arc welding
22. Parts of an oxyacetylene outfit
23. Factors that determine selection of welding tip size
24. Stages of oxyacetylene torch combustion
25. Types of ocyacetylene flames
26. Flashback and backfire
27. Steps to follow in case of flashback
28. Causes of backfire
29. Advantages and disadvantages of oxyacetylene braze welding
30. Importance of having a chemically clean metal surface in braze welding
31. Methods of removing oxides from a metal surface
32. Reactions of molten bronze at different temperatures
33. Parts of a torch body and cutting attachment

Application: What the Student Should Be Able to Do

34. Start, stop, and restart a bead
35. Construct a pad weld
36. Construct a butt weld
37. Construct a lap-joint fillet weld in the flat position
38. Construct a T-joint fillet weld in the flat position
39. Set up equipment for oxyacetylene welding/cutting
40. Turn on, light, adjust, and turn off oxyacetylene welding equipment
41. Braze weld a lap joint
42. Cut mild steel at a 90° angle, stop, and restart the cut
43. Cut round stock

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each assignment sheet and job sheet.

A matrix for each of the ten broad skill areas has been included in this edition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000,* a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want,* a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources.

Each of the ten broad skill areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, critical thinking, employability, social studies, and technology—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development
- Resource Management
- Job Safety

Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

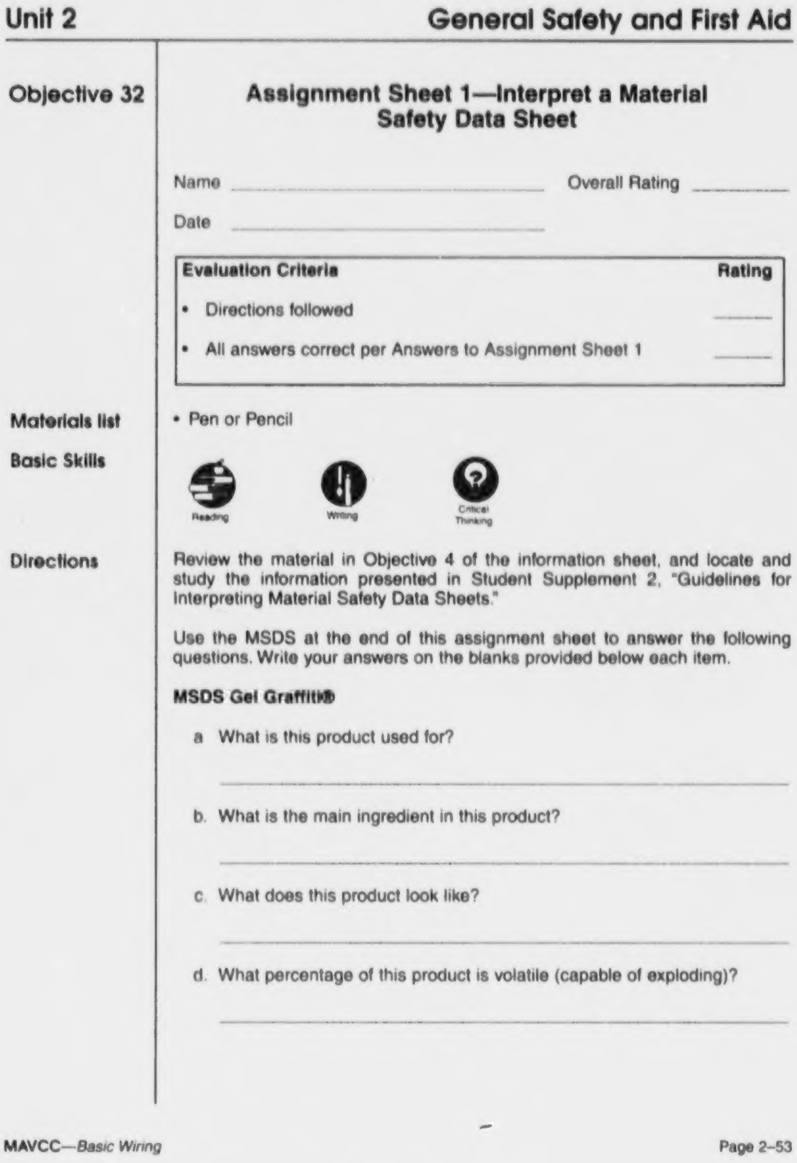
Technology Skills

- Selection
- Application
- Maintenance/Troubleshooting

Basic Skills Icons and Classifications

When an activity involving one of these basic skills is identified, the corresponding icon is placed in the left-hand margin of the assignment sheet and job sheet. Skills training is further defined by classifying specific skills that are required. (See skills list that may be found on each basic skills matrix.)

Example:



Unit 2 **General Safety and First Aid**

Objective 32

Assignment Sheet 1—Interpret a Material Safety Data Sheet

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	**Rating**
• Directions followed	____
• All answers correct per Answers to Assignment Sheet 1	____

Materials list • Pen or Pencil

Basic Skills

Reading Writing Critical Thinking

Directions Review the material in Objective 4 of the information sheet, and locate and study the information presented in Student Supplement 2, "Guidelines for Interpreting Material Safety Data Sheets."

Use the MSDS at the end of this assignment sheet to answer the following questions. Write your answers on the blanks provided below each item.

MSDS Gel Graffiti®

a What is this product used for?

____

b. What is the main ingredient in this product?

____

c. What does this product look like?

____

d. What percentage of this product is volatile (capable of exploding)?

____

MAVCC—*Basic Wiring* Page 2-53

Section A: Workplace Tools

Unit 1-A: Overview of Diesel-Powered Vehicles

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
19	Identify features for assigned on-road vehicle. (J.S. 1)		Reading	Reading comprehension	Identifies relevant details and specifications; uses written resources to obtain information.
			Writing	Language	Presents answers in a clear and understandable form; takes notes from various sources; uses technical words, symbols, and/or abbreviations.
			Math	Functional math	Makes measurements
		?	Critical Thinking	Cognitive activities	Collects/records information
			Employability	Job safety	Follows safety procedures; understands importance of safety to the organization
20	Identify features for assigned off-road vehicle. (J.S. 2)		Reading	Reading comprehension	Identifies relevant details and specifications; uses written resources to obtain information.
			Writing	Language	Presents answers in a clear and understandable form; takes notes from various sources; uses technical words, symbols, and/or abbreviations.
			Math	Functional math	Makes measurements
		?	Critical Thinking	Cognitive activities	Collects/records information
			Employability	Job safety	Follows safety procedures; understands importance of safety to the organization

Basic Skills Matrix

Unit 2-A: Basic Tools and Equipment

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
14	Use tool catalogs to determine the cost of a quality hand tool set. (A.S. 1)	📚	Reading	Reading comprehension	Follows written directions; determines what information is needed; uses standard occupational resource materials (catalogs and price lists) to obtain information
		🔢	Math	Functional math	Performs basic computations—addition and multiplication
		?	Critical Thinking	Cognitive activities	Evaluates information/data to choose between alternatives
		⛑	Employability	Job safety	Chooses tools that will produce the desired results
15	Dress a grinding wheel. (J.S. 1)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		⛑	Employability	Job safety	Demonstrates safe use of tools, equipment, and supplies
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
16	Sharpen a twist drill bit. (J.S. 2)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		🔢	Math	Math applications	Applies geometry principles
		⛑	Employability	Job safety	Demonstrates safe use of tools, equipment, and supplies
		?	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 2-A: Basic Tools and Equipment (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
17	Drill holes with a drill press. (J.S. 3)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		🔢	Math	Functional math	Makes measurement
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⛑	Employability	Job safety	Demonstrates safe use of tools, equipment, and supplies
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
18	Sharpen a cold chisel. (J.S. 4)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⛑	Employability	Job safety	Demonstrates safe use of tools, equipment, and supplies
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
19	Use a file. (J.S. 5)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⛑	Employability	Job safety	Demonstrates safe use of tools, equipment, and supplies
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Basic Skills Matrix

Unit 3–A: Reference Materials

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
8	Interpret drawings used in diesel equipment reference materials. (A.S. 1)	📚	Reading	Reading comprehension; functional reading	Follows written directions; interprets drawings to obtain information
		✏	Writing	Language	Presents answers in a clear and understandable form
		💡	Critical Thinking	Cognitive activities	Analyzes information presented in drawings
9	Interpret graphs used in diesel equipment reference materials. (A.S. 2)	📚	Reading	Reading comprehension; functional reading	Follows written directions; interprets drawings to obtain information
		✏	Writing	Language	Presents answers in a clear and understandable form
		💡	Critical Thinking	Cognitive activities	Analyzes information presented in graphs
10	Interpret diagrams used in diesel equipment reference materials. (A.S. 3)	📚	Reading	Reading comprehension; functional reading	Follows written directions; interprets drawings to obtain information
		✏	Writing	Language	Presents answers in a clear and understandable form
		💡	Critical Thinking	Cognitive activities	Analyzes information presented in diagrams
11	Interpret tables used in diesel equipment reference materials. (A.S. 4)	📚	Reading	Reading comprehension; functional reading	Follows written directions; interprets drawings to obtain information
		✏	Writing	Language	Presents answers in a clear and understandable form
		💡	Critical Thinking	Cognitive activities	Analyzes information presented in tables

Unit 3-A: Reference Materials (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
12	Use reference materials to answer specific questions. (A.S. 5)	📚	Reading	Reading comprehension	Follows written directions; determines what information is needed; uses standard occupational resource materials (service manuals, etc.) to obtain information
		✏	Writing	Language	Presents answers in a clear and understandable form
		💡	Critical Thinking	Cognitive activities	Locates appropriate reference materials to acquire information; analyzes information from a variety of resources

Basic Skills Matrix

Unit 4–A: Measuring Instruments

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
24	Read U.S. customary and metric rules. (A.S. 1)		Reading	Reading comprehension	Follows written directions; determines what information is needed; interprets drawings to obtain information
			Math	Application	Applies mathematical principles to determine measurements; uses U.S. customary and metric measurement systems
25	Draw lines to specified lengths. (A.S. 2)		Reading	Reading comprehension	Follows written directions; determines what information is needed
			Math	Application	Applies mathematical principles to determine measurements; uses U.S. customary and metric measurement systems; draws specified lengths using a steel rule
26	Measure lines using a steel rule. (A.S. 3)		Reading	Reading comprehension	Follows written directions; determines what information is needed
			Math	Application	Applied mathematical principles to determine measurements; uses U.S. customary and metric measurement systems; measures specified lengths
27	Measure lines on objects. (A.S. 4)		Reading	Reading comprehension	Follows written directions; determines what information is needed
			Math	Application	Applies mathematical principles to determine measurements; uses U.S. customary measurement system; measures specified lengths using a steel rule; reduces fractions to lowest terms
28	Measure circle diameters. (A.S. 5)		Reading	Reading comprehension	Follows written directions; determines what information is needed
			Math	Application	Applies mathematical principles to determine measurements; uses U.S. customary measurement system; measures specified lengths using a steel rule; reduces fractions to lowest terms
29	Read standard and metric micrometers. (A.S. 6)		Reading	Reading comprehension	Follows written directions; determines what information is needed; analyzes and applies what has been read to work-related tasks
			Math	Application	Applies mathematical principles to determine measurements; uses U.S. customary and metric measurement system
30	Use a dial caliper. (J.S. 1)		Reading	Reading comprehension	Reads and follows instructions to operate technical equipment
			Math	Data analysis and display	Records accurate data
			Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 4-A: Measuring Instruments (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
31	Use outside micrometer. (J.S. 2)		Reading	Reading comprehension	Reads and follows instructions to operate technical equipment
			Math	Application	Applies mathematical principles to determine measurements; makes precision measurements using outside micrometer
			Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
32	Use inside micrometer. (J.S. 3)		Reading	Reading comprehension	Reads and follows instructions to operate technical equipment
			Math	Application; functional math	Applies mathematical principles to determine measurements; makes precision measurements using inside micrometer
			Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
33	Use telescoping gauges. (J.S. 4)		Reading	Reading comprehension	Reads and follows instructions to operate technical equipment
			Math	Data analysis and display	Records accurate data
			Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
34	Use a dial indicator. (J.S. 5)		Reading	Reading comprehension	Reads and follows instructions to operate technical equipment
			Math	Application	Applies mathematical principles to determine measurements; makes precision measurements using dial indicator
			Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Basic Skills Matrix

Unit 4-A: Measuring Instruments (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
35	Check a torque wrench for accuracy. (J.S. 6)	📚	Reading	Reading comprehension	Reads and follows instructions to operate technical equipment
		🔢	Math	Functional math	Checks measuring instrument for accuracy
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Applications	Demonstrates the proper procedure for setting up and operating equipment
36	Use a small hole gauge to measure valve guide diameter. (J.S. 7)	📚	Reading	Reading comprehension	Reads and follows instructions to operate technical equipment
		🔢	Math	Application; functional math	Applies mathematical principles to determine measurements; makes precision mesurements using measuring devices
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
37	Use a cylinder bore gauge. (J.S. 8)	📚	Reading	Reading comprehension	Reads and follows instructions to operate technical equipment
		🔢	Math	Data analysis and display; functional math	Collects/records data; applies mathematical principles to determine measurements
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 5-A: Shop Operation

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
10	Complete a job ticket. (A.S. 1)	📚	Reading	Reading comprehension	Follows written directions; identifies relevant details; determines what information is needed
		✎	Writing	Language	Completes form accurately; writes legibly
		2 7 +6 4 5	Math	Functional math	Applies computation skills as they are actually used on the job
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
11	Use a computer system to obtain parts information. (J.S. 1)	📚	Reading	Reading comprehension	Reads and follows instructions to operate technical equipment; determines what information is needed
		✎	Writing	Language	Presents answers in a clear and understandable form
		💡	Critical Thinking	Cognitive activities	Uses available resources to acquire new skills or improve skills; applies new skills to job duties
		⚛	Technology	Application	Uses computer to acquire, organize, analyze, and communicate information

Basic Skills Matrix

Section B: Common Materials

Unit 1-B: Mechanical Fasteners

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
16	Measure U.S. customary bolts and threads. (A.S. 1)	📚	Reading	Reading comprehension	Follows written directions; applies information to new situations; determines what information is needed
		🔢	Math	Functional math	Takes measurements using common measuring devices/tools; uses U.S. customary measurement system
		💡	Critical Thinking	Cognitive activities	Collects/records information
17	Measure metric bolts and threads. (A.S. 2)	📚	Reading	Reading comprehension	Follows written directions; applies information to new situations; determines what information is needed
		🔢	Math	Functional math	Takes measurements using common measuring devices/tools; uses U.S. customary measurement system
		💡	Critical Thinking	Cognitive activities	Collects/records information
18	Match bolts with the correct size wrenches. (A.S. 3)	📚	Reading	Reading comprehension	Follows written directions; uses tables to obtain factual information
19	Extract a broken bolt, stud, or screw. (J.S. 1)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚙	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
20	Restore external threads. (J.S. 2)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚙	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 1-B: Mechanical Fasteners (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
21	Cut and restore internal threads. (J.S. 3)	●	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		●	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		●	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
22	Install a thread insert. (J.S. 4)	●	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		●	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		●	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Basic Skills Matrix

Unit 2-B: Lines, Fittings, and Couplings

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
17	Describe characteristics of pipe, tubing, and hose. (A.S. 1)	📚	Reading	Reading comprehension	Follows written instructions; uses tables to obtain factual information; applies information to new situations
		🔢	Math	Data analysis and display	Interprets charts and tables
		💡	Critical Thinking	Cognitive activities	Collects/records information
18	Identify fittings and threads. (A.S. 2)	📚	Reading	Reading comprehension	Follows written instructions; analyzes and applies what has been read to specific task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
19	Replace a skive hose end. (J.S. 1)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		🔢	Math	Fuctional math	Makes measurements
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
20	Replace a no skive hose end. (J.S. 2)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		🔢	Math	Functional math	Makes measurements
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 3-B: Seals and Bearings

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
23	Install a radial lip seal. (J.S. 1)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
24	Remove and install an engine oil seal and wear sleeve. (J.S. 2)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
25	Install a packing. (J.S. 3)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
26	Replace a formed gasket. (J.S. 4)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
27	Replaced a formed-in-place gasket. (J.S. 5)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Basic Skills Matrix

Unit 3-B: Seals and Bearings (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
28	Remove and install a camshaft friction bearing. (J.S. 6)	●	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		●	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		●	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
29	Remove and install an anti-friction bearing. (J.S. 7)	●	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		●	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		●	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
30	Clean and pack an antifriction bearing. (J.S. 8)	●	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		●	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		●	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 4-B: Fluids and Lubricants

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
32	Test for combustion leakage into a cooling system. (J.S. 1)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		?	Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
33	Test for air in cooling system. (J.S. 2)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		?	Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
34	Clean a cooling system. (J.S. 3)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		?	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
35	Change oil and oil filter. (J.S. 4)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		?	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Basic Skills Matrix

Section C: Basic Related Principles

Unit 1-C: Basic Electrical Principles

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
21	Solve problems using Ohm's law. (A.S. 1)	📚	Reading	Reading comprehension	Follows written directions; determines what information is needed; applies/understands technical words
		🔢	Math	Fundamental math	Performs basic computations—multiplications and division; applies mathematical formula to solve problems; shows calculation work
		💡	Critical Thinking	Cognitive activities	Solves for unknown values
22†	Interpret electrical values from multimeter settings. (A.S. 2)	📚	Reading	Reading comprehension	Follows written directions; analyzes and applies what has been read to specific task; applies technical words
		🔢	Math	Operation and calculation	Calculates different units of measurement
		💡	Critical Thinking	Cognitive activities	Interprets drawings to solve problems
23	Interpret wiring diagrams. (A.S. 3)	📚	Reading	Reading comprehension	Follows written directions; locates pertinent information in diagrams; determines what information is needed
		💡	Critical Thinking	Cognitive activities	Interprets drawings to solve problems
24	Measure current, voltage, and resistance with a multimeter. (J.S. 1)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task; uses standard occupational resource materials (service manuals) to obtain information
		🔢	Math	Fundamental math	Takes measurements using multimeter
		💡	Critical Thinking	Cognitive activities	Analyze/synthesize information
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
25	Test and replace light bulbs and test sockets. (J.S. 2)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 1-C: Basic Electrical Principles (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
26	Tin a soldering iron or gun. (J.S. 3)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
27	Solder-splice electrical wiring. (J.S. 4)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
28	Install terminals and connectors. (J.S. 5)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
29	Test charge a conventional (non-sealed) battery. (J.S. 6)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
30	Test charge a sealed battery. (J.S. 7)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 1-C: Basic Electrical Principles (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
31	Slow charge a battery. (J.S. 8)		Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
			Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
32	Perform a battery load test. (J.S. 9)		Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
			Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
33	Perform high-rate battery charge test. (J.S. 10)		Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
			Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
34	Emergency jump-start a vehicle. (J.S. 11)		Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
			Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
			Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 2-C: Basic Hydraulic Principles

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
17	Draw a block diagram of a simple hydraulic system. (A.S. 1)	●	Reading	Reading comprehension	Follows written directions; applies information and concepts derived from printed materials
		●	Science	Physical science	Applies principles and concepts of physics—fluid power, energy resources
		●	Critical Thinking	Cognitive activities	Creates block diagram to demonstrate hydraulics
18	Perform general maintenance procedures on a hydraulic system. (J.S. 1)	●	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		●	Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
		●	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
19	Change hydraulic fluid and filter. (J.S. 2)	●	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		●	Critical Thinking	Cognitive activities	Identifies possible reasons for problem; draws conclusions from observations
		●	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Basic Skills Matrix

Unit 3-C: Basic Welding and Cutting

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
34	Start, stop, and restart a bead. (J.S. 1)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
35	Construct a pad weld. (J.S. 2)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
36	Construct a butt weld. (J.S. 3)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
37	Construct a lap-joint fillet weld in the flat position. (J.S. 4)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
38	Construct a T-joint fillet weld in the flat position. (J.S. 5)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Unit 3-C: Basic Welding and Cutting (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
39	Set up equipment for oxyacetylene welding/cutting. (J.S. 6)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
40	Turn on, light, adjust, and turn off oxyacetylene welding equipment. (J.S. 7)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
41	Braze weld a lap joint. (J.S. 8)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
42	Cut mild steel at a 90° angle, stop, and restart the cut. (J.S. 9)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment
43	Cut round stock. (J.S. 10)	📚	Reading	Reading comprehension	Follows written directions; comprehends written information and applies it to a task
		💡	Critical Thinking	Cognitive activities	Transfers knowledge/training to new situations
		⚛	Technology	Application	Demonstrates the proper procedure for setting up and operating equipment

Tools, Equipment, and Materials List

Adhesive
Antifreeze
Apron, rubber
Battery, sealed
Battery, conventional (non-sealed)
Battery charger
Bearing, camshaft friction
Bearing, camshaft friction remover and installer tool
Bearing packer
Bearing puller or press
Blocks, support
Bolt, damaged needing repair
Box, slag
Brush, wire or file card
Brush, bristle
Brush, socket-cleaning
Caliper, dial, standard or metric
Chisel, cold
Chisel gauge
Clamp
Cleaners, tip (welding)
Cloth, emery
Cloth, lint-free
Clothing, protective (for welding)
Components to be measured
Computer system with parts information
Computer diskettes or CDs
Container for water
Cord, strong
Covers, fender
Degreaser
Die
Die stock
Drill, hand, twist with bits
Drill gauge
Drill press
Electrodes, welding
Electrode holder with lead
Engine head with valve guides to be measured
Engine with cam bearings
Extractors, screw
File with handle
Filter, coolant
Filter, oil, element-type and/or cartridge-type
Filler rod, bronze
Firebricks, 2
Fire extinguisher, multipurpose
Flashlight
Flux, cleaning solution
Flux, welding
Gasket
Gasket, oil filter housing
Gasket remover
Gauge, cylinder bore
Gauge, small hole set
Gauge, telescoping set
Gloves, leather (welding)
Gloves, rubber
Grease, bearing
Grinder and grinding wheel
Grinder dressing tool
Ground clamp with lead (welding)
Hammer, ball peen
Hammer, chipping
Hand tools, basic set
Heat gun
Heat-shrink insulation
Hose, replacement
Hose ends, skive type
Hose ends, no skive type
Hydraulic filter
Hydraulic fluid
Hydrometer
Indicator, dial set
Jumper cables
Knife
Lighter, flint (welding)
Line to be measured
Metal, flat, small piece
Micrometer, outside, standard or metric
Micrometer, inside, standard or metric
Multimeter
Off-road vehicle
Oil, engine
Oil, cutting
Oil, light machine
Oil, lubricating
Oil, tinning
On-road vehicle
Oxyacetylene welding/cutting outfit
Packings

Tools, Equipment, and Materials List

Paintbrush
Pan, drain
Paper
Pencil
Pliers, light-bulb
Pliers, slip joint
Punch, center
Razor blade
Safety equipment—glasses, etc.
Screwdriver
Seal, radial lip type
Seal, engine oil type
Seal installation tool
Seal removal tool
Sealant
Service manuals
Service sticker
Soapstone
Soapsuds
Sodium carbonate
Solder, rosin-core on roll
Soldering iron or gun (with replaceable tips)
Solvent, cleaning
Sponge, clean
Stand, engine
Steel, mild, several pieces (for welding)
Steel rule
Stock to be filed
Stock to be drilled and threaded
Table, welding or cutting
Taps, cutting and rethreading
Tape, electrical
Tape measure, 50′
Terminals and connectors
Thermometer
Thread insert and insert installation tool (or kit)
Towels, shop
Tube, transparent plastic
Water
Wear sleeve
Wear sleeve installation tool
Weight, "known"
Welding machine
Welding shield or helmet
Wire stripping and crimping tool
Wooden block
Wrench, filter
Wrench, tap
Wrench, torque
Wrenches, assorted
Vise
Volt-amp tester
Voltmeter

Unit 1-A Overview of Diesel-Powered Vehicles

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 1A-3
Written Test 1A-7
Answers to Written Test 1A-17
Learning Activities Sheet 1A-21
Transparency Masters
  1—Basic On-Road Vehicles 1A-23
  2—Basic Off-Road Vehicles: Agricultural 1A-25
  3—Basic Off-Road Vehicles: Construction/Industrial 1A-27
  4—Basic Off-Road Vehicles: Construction/Industrial (continued) . . 1A-29
  5—Types of Trailers 1A-31
  6—Types of Trailers (continued) 1A-33
  7—Truck Dimensions 1A-35
  8—Agricultural Tractor Dimensions 1A-37

Student Components

Student Page

Objective Sheet 1A-3
Information Sheet 1A-5
Job Sheets
  1—Identify Features for Assigned On-Road Vehicle 1A-23
  2—Identify Features for Assigned Off-Road Vehicle 1A-25

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to the unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Contact local dealers/distributors or service centers for promotional sales literature showing the types of on-road and off-road vehicles being produced today. Include examples of truck-tractors, agricultural equipment, and construction equipment, as well as any specialty equipment that is commonly worked on in your shop. Also get prices for new vehicles if possible.

- Discuss the many types of vehicles that use diesel engines. Point out examples available in your shop, and then discuss other less common vehicles that students may also work on during this course. Show pictures of equipment if actual equipment is not available.

- Discuss the changes made between old designs and new designs and why the manufacturer made the new designs. Show students pictures of old vehicles and new vehicles, and have them point out the design changes and why they may have been made.

- Have students point out the major differences and major similarities between on-road vehicles and off-road vehicles. Make a list of both the differences and similarities. Discuss how service of both is different and similar.

- Take students on a walkaround of a diesel-powered vehicle to show all of the systems (electrical, braking, suspension, etc.) Discuss the functions of the different systems and show how they work together.

- Provide students with information about obtaining a commercial driver's license. This is required in most states before technicians can road test vehicles.

- Assign on-road and off-road vehicles that students can use in completing Job Sheets 1 and 2.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper*, Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals*, Stillwater, OK. Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair*, 3rd edition. Upper Saddle River, NJ: Prentice Hall, 1994.

- *Introduction to Automotive Service.* Stillwater, OK: Curriculum and Instructional Material Center/Oklahoma Department of Vocational and Technical Education, 1989.
- *Fundamental of Service: Engines.* Moline, IL: Deere & Company, 1991.
- Schultz, Erich J. *Diesel Mechanics*, 4th ed. New York: Glencoe/McGraw-Hill, 1999.
- *Truck Systems Design Handbook.* Warrendale, PA: Society of Automotive Engineers, Inc., 1992.
- *Vehicle Aerodynamics: Recent Progress.* Warrendale, PA: Society of Automotive Engineers, Inc., 1991.

Suggested Supplemental Resources

Print Media

- *Truck Talk!* (SDF-013)
- *Dawn of the Century* (SDF-020)

The items above are available from:

Freightliner Corporation
Technical Training Department
5169 N. Lagoon Avenue
Portland, OR 97217

Written Test

Name ______________________________

Date ______________________________ Score __________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Cab
2. Chassis
3. Circuit
4. Clearance (marker) lights
5. Component
6. Drive component
7. Fairing
8. Fifth wheel
9. Friction
10. Kingpin
11. Off-road vehicles
12. On-road vehicles
13. Pintle hitch
14. Reflectors
15. Running gear
16. Semitrailer
17. System
18. Vehicle design

_____ a. Coupling mechanism on the tractor that joins the truck-tractor to the trailer

_____ b. Combined parts of a trailer that allow it to be pulled down the road

_____ c. Circular path of a gas, liquid, or electrical power system

_____ d. Vehicles used for non-highway purposes such as construction or agricultural work

_____ e. Resistance to motion between two parts in contact

_____ f. Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system

_____ g. Type of freight trailer that is supported on its forward end by the fifth wheel on the truck-tractor

_____ h. Coupling mechanism that joins two trailers together

_____ i. Supporting frame of a vehicle; everything below the cab

_____ j. Pin on the trailer that connects to the tractor's fifth wheel

_____ k. Vehicles used on highways and interstates for the transportation of goods, raw materials, services, or people

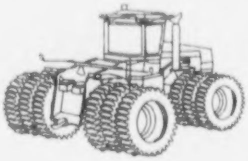
_____ l. Member or structure whose primary function is to produce a smooth outline and to reduce drag

____ m. Part of the power/drive train that has engine power applied to it to make the vehicle move

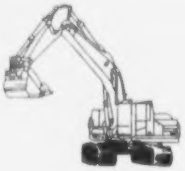
____ n. Plan of the elements of a vehicle, including their shape, the materials they are made of, and the way they fit together and function to achieve certain purposes

Objective 2

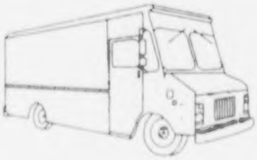
Identify the following common diesel-powered vehicles. Write your answers in the blanks provided.



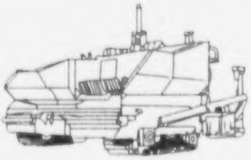
a. ______________________



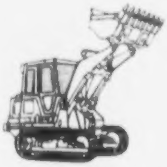
b. ______________________



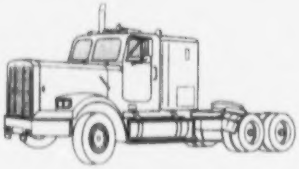
c. ______________________



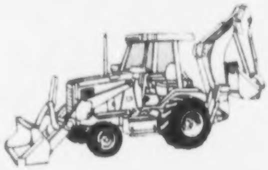
d. ______________________



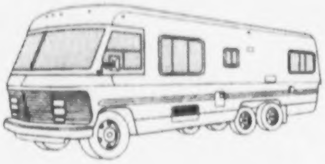
e. ______________________



f. ______________________



g. ______________________



h. ______________________

Objective 3

List three reasons for new vehicle designs.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 4

Complete the following statements concerning the major functional areas of vehicles by filling in the blanks with the correct answers.

a. The ______________ includes the engine, engine brakes, and drive train.

b. The cylinder arrangement of the engine is either ______________ or ______________.

c. The three major functional areas of vehicles are ______________, ______________, and ______________.

d. The ______________ varies the ratio of engine RPMs to driveshaft RPMs to maintain optimum power through vehicle's range of speed.

e. The ______________ transmits power from driveshaft to axle and permits drive wheels to turn at different speeds when going through a turn.

f. The ______________ connects components in drive line and enables them to operate at different angles.

Objective 5

Match the major vehicle systems with their descriptions. Descriptions continue on the next page.

1. Brake system
2. Computer-control system
3. Electrical system
4. Engine cooling system
5. Engine lubrication system
6. Exhaust system
7. Fuel system
8. Heating and air conditioning system
9. Steering system
10. Suspension system

_____ a. Absorbs shock that results from wheels or tracks hitting holes or bumps on operating surface

_____ b. Directs harmful gases and heat away from engine and operator

_____ c. Allows operator to reduce speed of or stop moving vehicle

_____ d. Powers safety and warning devices, convenience accessories, and lights

____ e. Provides fuel storage

____ f. Circulates either air only or air and liquid to transfer heat of combustion and friction away from engine to prevent engine damage

____ g. Heats or cools, dehumidifies, cleans, and then delivers warm or cool air to cab

____ h. Allows driver to control direction of vehicle

____ i. Electronically monitors and adjusts the operation of various systems and provides driver and service technician with information about those systems

Objective 6

Distinguish among truck weights by placing:

- GVW = next to gross vehicle weight
- PW = next to payload weight
- TW = next to tare weight

_____ a. Weight of the commodity to be carried

_____ b. Weight of the vehicle when empty

_____ c. Weight of the vehicle when loaded

Objective 7

State gross vehicle weight ranges for on-road truck weight classifications.

a. Class 1: ______________________________

b. Class 4: ______________________________

c. Class 6: ______________________________

d. Class 8: ______________________________

Objective 8

Complete the following chart of axle and drive wheel configurations by filling in the blanks with the correct numbers.

Motor Vehicle	Total Wheels	Driven Wheels	Total Axles	Drive Axles
4 x 2	4	2	a. ______	b. ______
4 x 4	4	c.______	2	2
6 x 2	6	2	d. ______	1
6 x 4	e. ______	4	3	2
6 x 6	6	6	3	3
8 x 4	8	4	f. ______	g. ______
8 x 8	8	h. ______	4	i. ______

Objective 9

Distinguish between basic truck cab designs by placing:

- C = next to conventional cab
- COE = next to cab-over-engine

_____ a. Cab sits behind the engine

_____ b. Shorter wheelbase allows for easier handling in traffic

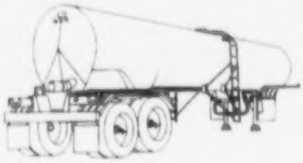
_____ c. Driver is seated as far forward as possible which provides greater visibility

_____ d. Offers driver a smoother ride and more protection because frame and engine are out front

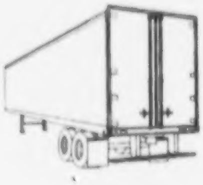
_____ e. Entire cab must be tilted up and forward for access to engine

Objective 10

Identify the following common types of trailers. Write your answers in the blanks provided.

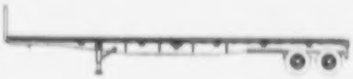


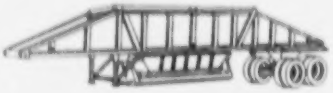
a. ______________________



b. ______________________

Written Test





c. ______________________ d. ______________________

Objective 11

Match the parts of a trailer with their descriptions.

1. Air system
2. Axles
3. Brakes
4. Bulkhead
5. Doors
6. Floor, walls, (inside and outside), ceiling, and roof
7. Inside or outside rails
8. King pin
9. Landing gear
10. Lights and electrical wiring
11. Sliding tandems
12. Suspension system
13. Tires
14. Wheels

_____ a. Locks into the tractor's fifth wheel to connect the trailer to the tractor

_____ b. Consists of two couplings ("glad hands") that transmit air pressure from the tractor to the trailer brakes

_____ c. Include clearance lights, turn signals, parking lights, rear lights, and brake lights

_____ d. Used to adjust the wheelbase of the trailer to help distribute trailer weight

_____ e. Carry the weight of the cargo and transmit the load of the wheels

_____ f. Holds up the front of the trailer when the trailer isn't hooked to the tractor

_____ g. Wall on the front of a trailer that prevents cargo from sliding into tractor during stops

_____ h. Used to provide a smooth ride for driver and cargo

_____ i. Parts of the van's box shell that protect the cargo; commonly made of aluminum and reinforced, lightweight material such as fiberglass reinforced plastic. (FRP)

_____ j. Transmit the weight of the cargo from the wheels to the road; provide traction

Objective 12

Identify the following types of tractor-trailer combinations. Write your answers in the blanks provided.

a. ______________________

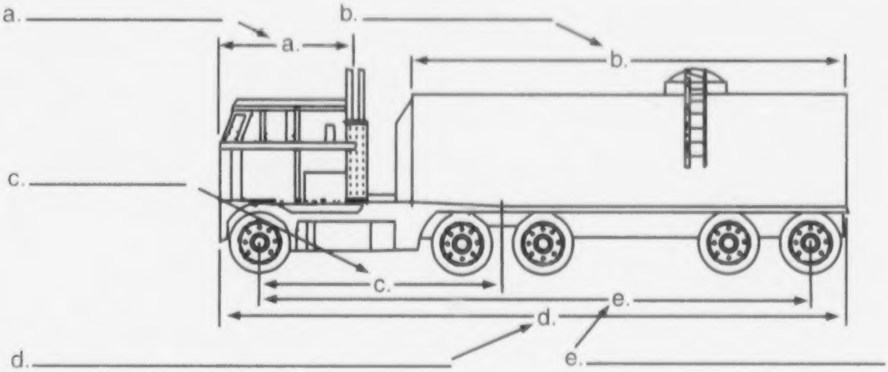
b. ______________________

c. ______________________

d. ______________________

Objective 13

Label the following truck dimensions.



a. ______________________

b. ______________________

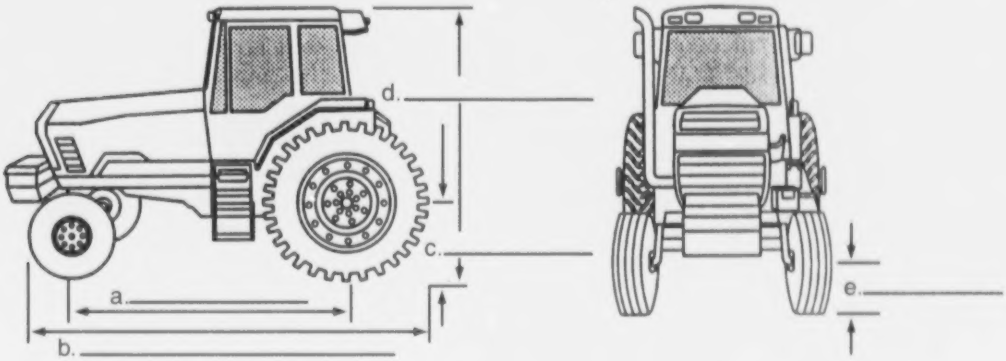
c. ______________________

d. ______________________

e. ______________________

Written Test

Objective 14 Label the following agricultural tractor dimensions.



Objective 15 Distinguish among terms related to tractors by placing:

- DM = next to deck machinery
- FD = next to final drive
- PTO = next to power takeoff

_____ a. Power train component that powers auxiliary systems or implements

_____ b. Equipment and machinery such as cranes, shovels, and loaders mounted on a turntable that allows it to rotate or swing

_____ c. Last gear in drive train to lower speed and raise torque before power reaches drive mechanism or driver sprocket

Objective 16 Select true statements concerning characteristics of final drives by placing a "T" next to true statements and an "F" next to false statements.

_____ a. A pinion gear is a common type of final drive gear.

_____ b. An outboard is located at the differential end and the axle shaft.

_____ c. A power gear is a common type of final drive gear.

_____ d. An inboard is located at the drive wheel and end of the axle shaft.

Objective 17

Complete the following statements concerning characteristics of power takeoffs by filling in the blanks with the correct answers.

a. A transmission driven power takeoff control operates only when the ____________________ is engaged.

b. Standard gear arrangements for power takeoffs include 520 rpm on 1 3/8" shaft or ____________________ rpm on 1 3/8" or 1 3/4" shafts.

c. Power takeoff controls may be transmission driven or ________________

Objective 18

Complete the following statements concerning deck machinery by circling the correct answers.

a. The top structural division of a typical deck machinery is the (**mounting, revolving**) unit.

b. A (**hoist, swing**) consists of deck-mounted drums that control in/out and up/down movement of boom-attachment.

c. A (**hoist, swing**).is an upper unit supported by rollers or bolts on a turntable, which rotates deck and boom in either direction.

d. The (**A-frame, gantry**).is a steel structure on machinery deck projecting high above cab roof; supports boom cables on large equipment.

Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 8
b. 15
c. 3
d. 11
e. 9
f. 5
g. 16
h. 13
i. 2
j. 10
k. 12
l. 7
m. 6
n. 18

Objective 2

a. 4-wheel drive tractor
b. Excavator
c. Van
d. Asphalt paver
e. Track-type loader
f. Truck-tractor without trailer
g. Backhoe loader
h. Recreational vehicle (RV) or motor home

Objective 3

Any three of the following:

a. For better fuel efficiency and lower costs
b. For easier service
c. For longer life
d. To improve overall performance
e. To improve driver comfort and safety
f. To improve highway and environment safety

Objective 4

a. Power train
b. V-type or in-line
c. Body, chassis, power train
d. Transmission
e. Differential
f. Universal joint

Objective 5

a. 10
b. 6
c. 1
d. 3
e. 7
f. 4
g. 8
h. 9
i. 2

Objective 6

a. PW
b. TW
c. GVW

Answers to Written Test

Objective 7

a. up to 6,000 pounds
b. 14,001 - 16,000 pounds
c. 19,501 - 26,000 pounds
d. 33,001 pounds and over

Objective 8

a. 2
b. 1
c. 4
d. 3
e. 6
f. 4
g. 2
h. 8
i. 4

Objective 9

a. C
b. COE
c. COE
d. C
e. COE

Objective 10

a. Tanker-type—Liquid
b. Van type—Dry freight
c. Flat bed
d. Bottom dump type

Objective 11

a. 8
b. 1
c. 10
d. 11
e. 2
f. 9
g. 4
h. 12
i. 6
j. 13

Objective 12

a. Turnpike double 45 ft. trailers
b. 3 axle tractor—semitrailer with 27 ft, trailer
c. Rocky mountain double—45 ft. and 27 ft. trailers
d. Triple 27-ft. trailers

Objective 13

a. BBC—Bumper to back of cab
b. TL—Semitrailer length
c. WB—Wheelbase
d. OAL—Overall length
e. OWB—Overall wheelbase

Objective 14

a. WB—Wheelbase
b. OAL—Overall length
c. DBC—Drawbar clearance
d. HOC—Height over cab
e. FAC—Front axle clearance

Answers to Written Test

Objective 15	a. PTO b. DM c. FD
Objective 16	a. T b. F c. F d. F
Objective 17	a. Clutch b. 1000 c. Independent
Objective 18	a. Revolving b. Hoist c. Swing d. Gantry

Unit 1-A Overview of Diesel-Powered Vehicles

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 and 2.

☐ 4. **Research** Online resources regarding other types of diesel-powered vehicles such as those used in logging and mining.

☐ 5. **Study** Information Sheet, Objectives 3 through 5.

☐ 6. **View** Illustrations in truck servcie manuals that show the major functional areas of vehicles and major vehicle systems. Compare with information presented in Objectives 4 and 5.

☐ 7. **Study** Information Sheet, Objectives 6 through 11.

☐ 8. **View** Illustrations in operator's manual or service manual that show the major parts of a trailer.

☐ 9. **Study** Information Sheet, Objectives 12 through 18.

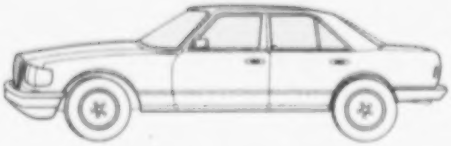
☐ 10. **Do** Job Sheet 1, "Identify Features for Assigned On-Road Vehicle."

☐ 11. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 10 and 11.

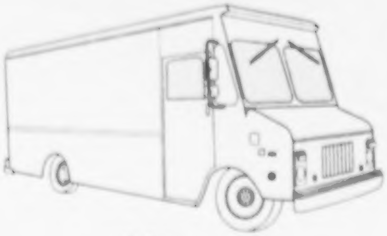
☐ 12.	**Do**	Job Sheet 2, "Identify Features for Assigned Off-Road Vehicle."
☐ 13.	**Stop**	Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 12 and 13.
☐ 14.	**Check**	With instructor for any additional assignments to be completed.
☐ 15.	**Do**	Additional assignments listed below. ____________________ ____________________ ____________________
☐ 16.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
☐ 17.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

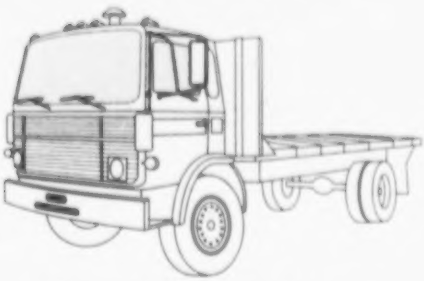
Basic On-Road Vehicles



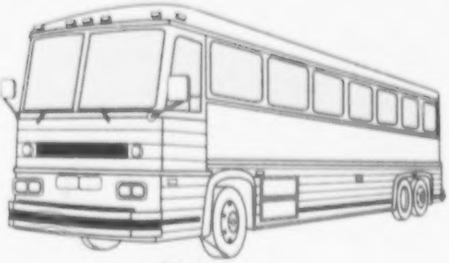
Automobile



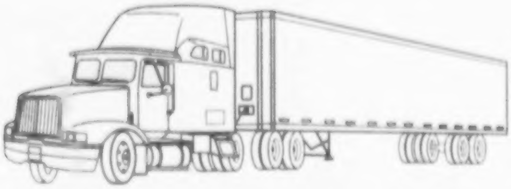
Van



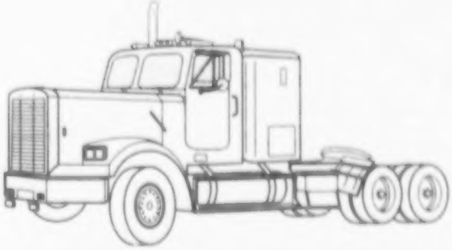
Straight truck
(Light-, medium-, or heavy-duty)



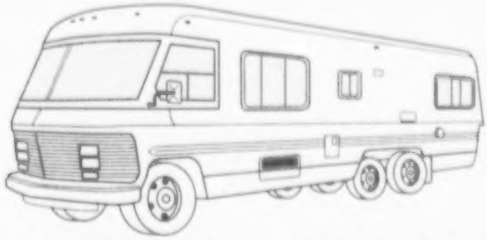
Bus



Truck-tractor with semitrailer connected



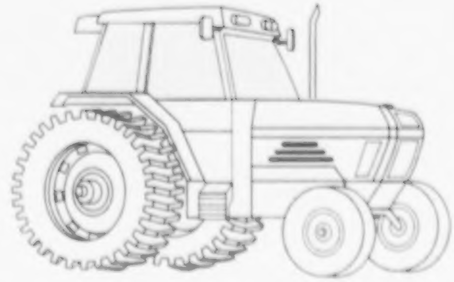
Truck-tractor without trailer (bobtail)



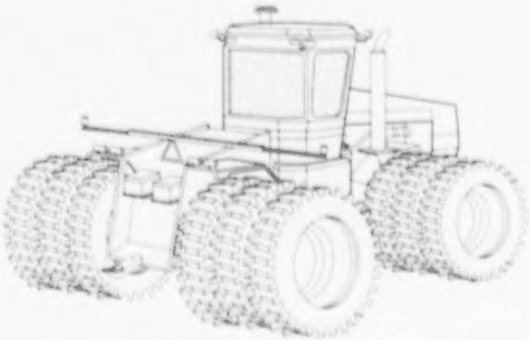
Recreational vehicle (RV) or motor home

Basic Off-Road Vehicles

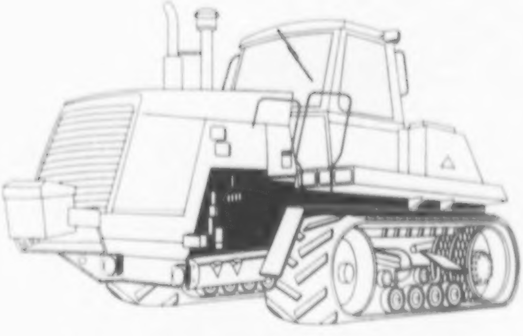
Agricultural



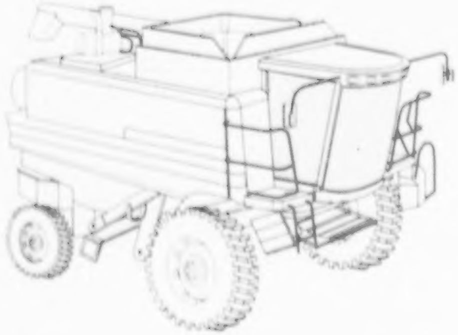
2-wheel drive tractor



4-wheel drive tractor

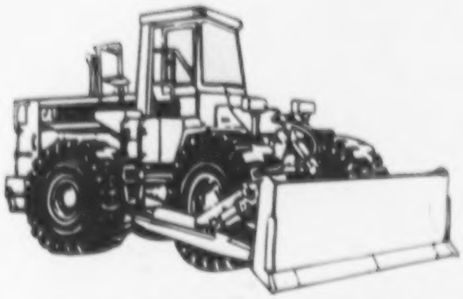


Track-type tractor

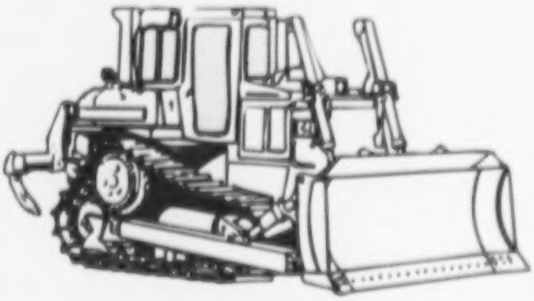


Combine/harvester

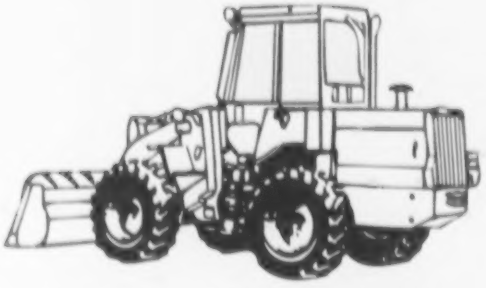
Basic Off-Road Vehicles
Construction/Industrial



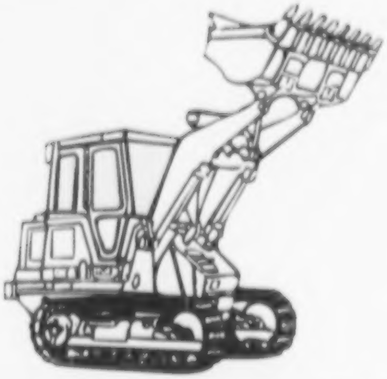
Wheel-type tractor



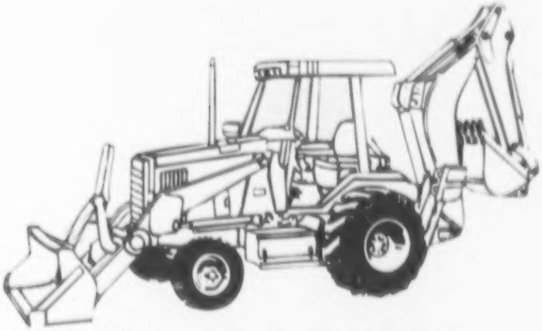
Track-type tractor



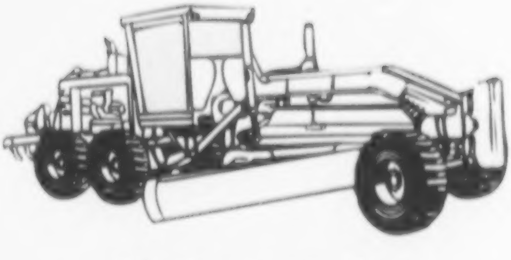
Wheel-type loader



Track-type loader



Backhoe loader



Motor grader

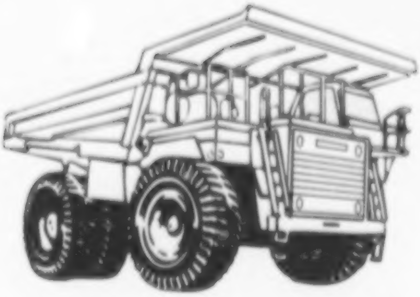
Permission to reprint granted by Caterpillar Inc.

TM 3

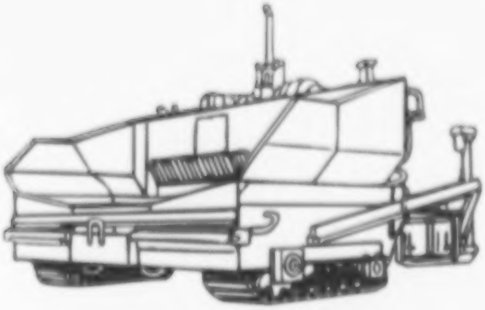
Basic Off-Road Vehicles

Construction/Industrial

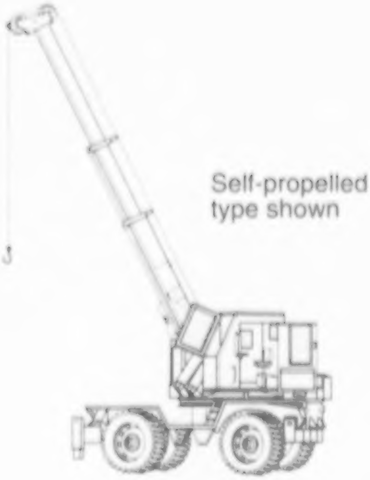
(Continued)



Off-road truck

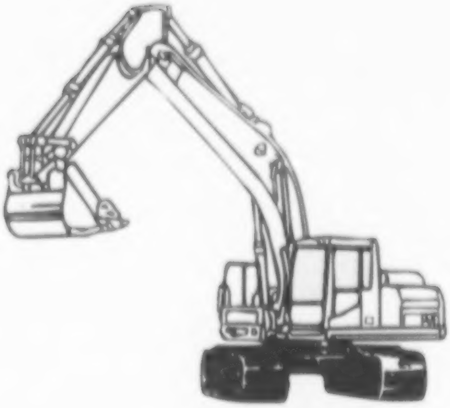


Asphalt paver



Self-propelled type shown

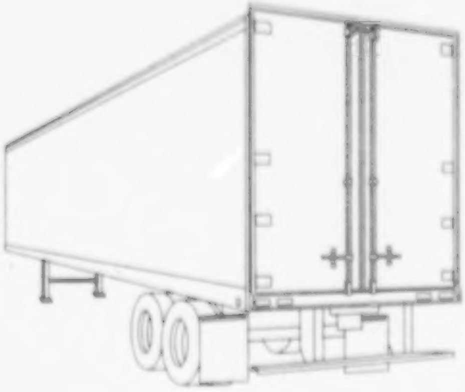
Crane



Excavator

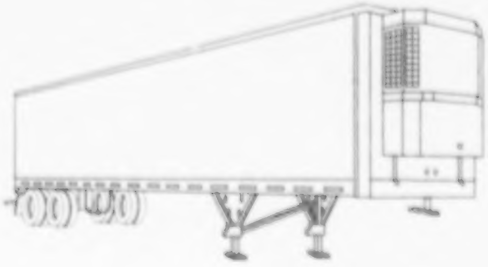
Permission to reprint granted by Caterpillar Inc.

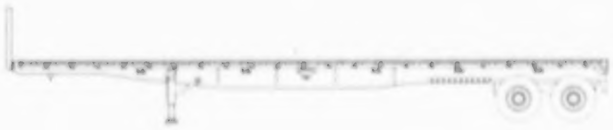
Types of Trailers



Dry freight van type trailer

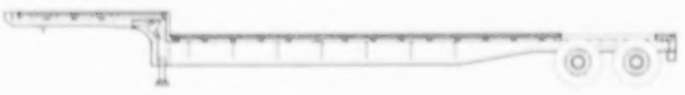
Refrigerated freight van type trailer





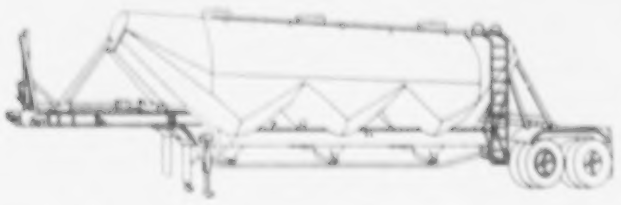
Flat bed trailer

Flat bed drop frame trailer

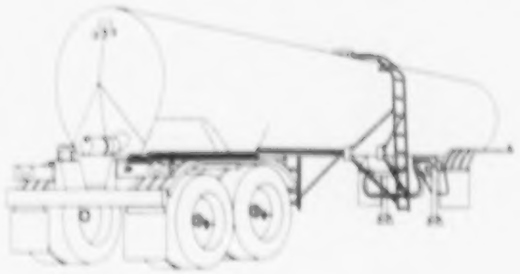


Types of Trailers

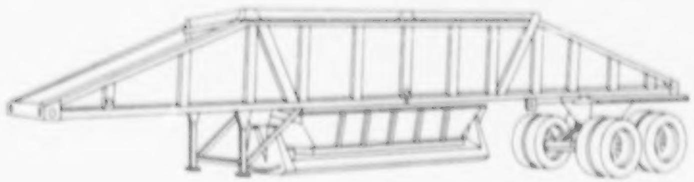
(Continued)



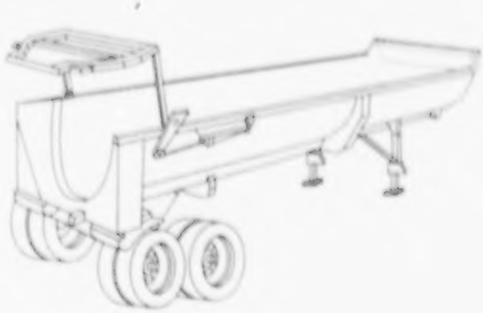
Dry bulk tanker type trailer



Liquid tanker type trailer

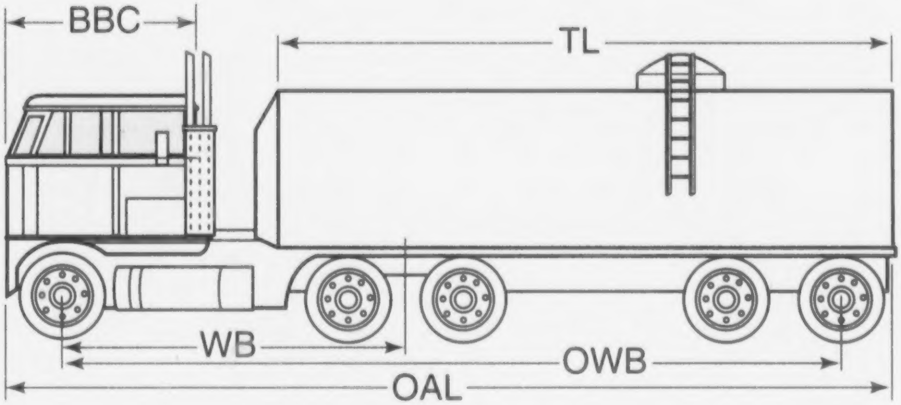


Bottom dump type trailer



End dump type trailer

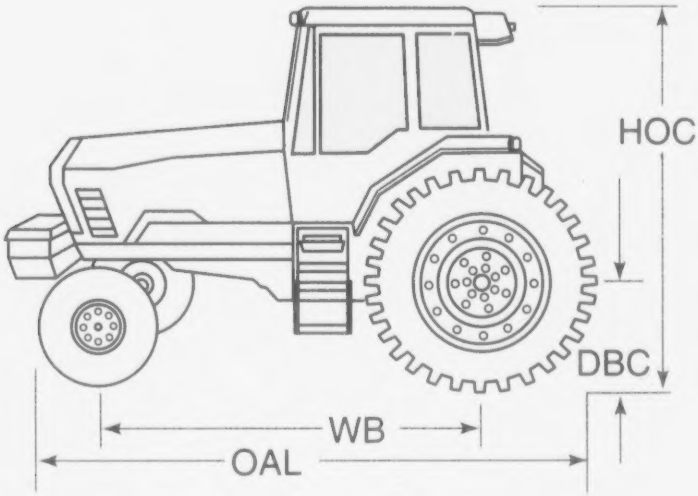
Truck Dimensions

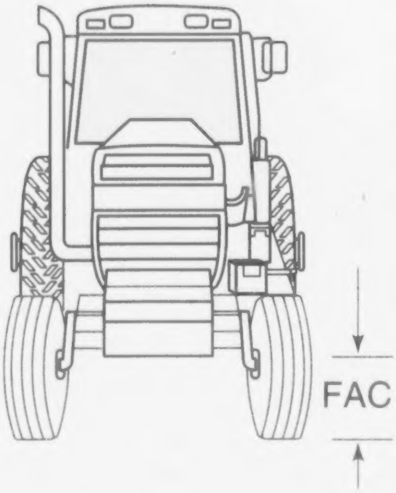


BBC	Bumper to back of cab
OAL	Overall length
OWB	Overall wheelbase
TL	Semitrailer length
WB	Wheelbase—distance between centerline of front and rear axle or tandem suspension

TM 7

Agricultural Tractor Dimensions





DBC	Drawbar clearance
FAC	Front axle clearance
HOC	Height over cab
OAL	Overall length
WB	Wheelbase

TM 8

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 2A-3

Written Test 2A-9

Answers to Written Test 2A-19

Learning Activities Sheet 2A-23

Transparency Masters

1—Types of Chisels & Punches 2A-27
2—Types of Files 2A-29
3—Types of Hammers 2A-31
4—Types of Pliers 2A-33
5—Types of Pliers (continued) 2A-35
6—Types of Pullers 2A-37
7—Types of Pullers (continued) 2A-39
8—Types of Screwdrivers 2A-41
9—Types of Wrenches 2A-43
10—Types of Wrenches (continued) 2A-45
11—Parts of a Socket Wrench Set 2A-47
12—Parts of a Socket Wrench Set (continued) 2A-49

Student Components

Student Page

Objective Sheet 2A-3

Information Sheet 2A-5

Assignment Sheet

1—Use Tool Catalogs to Determine the Cost of a Quality Hand Tool Set 2A-31

Job Sheets

1—Dress a Grinding Wheel 2A-35
2—Sharpen a Twist Drill Bit 2A-37
3—Drill Hole With a Drill Press 2A-41
4—Sharpen a Cold Chisel 2A-43
5—Use a File 2A-47

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of this activity.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Discuss the use and care appropriate for basic hand tools, power tools, and shop equipment.
- Demonstrate the safe operation of all tools and equipment that students will be using in the shop.
- Show the personal protective equipment (safety glasses, gloves, etc.) required when using various tools and equipment.
- Conduct safety tests (with students showing competence by return demonstrations), and document which students are competent and approved to operate which shop machines/equipment.
- Make a display of all basic hand tools included in this unit so students can hold them and see how they are used. Include as many examples of the following as possible.

  a. Chisels and punches

  b. Files

  c. Hammers

  d. Pliers

  e. Pullers

  f. Screwdrivers

  g. Wrenches

  h. Others

- Discuss storage required for hand tools, power tools, and shop equipment. Show students the appropriate storage area for tools and equipment.
- Discuss which tools and equipment will be used for various types of jobs in the shop. Give a mock demonstration of using tools for common shop operations.

- Invite a local area tool manufacturer's sales representative to visit your class/shop to discuss new tools and equipment or refinements on existing tools that are now available. Contact auto/diesel supply stores for possible speakers or more information about tool representatives.

  Examples: Snap-on, Mac Tools, NAPA, Craftsman, Black and Decker, etc.

- Provide current tool catalogs with price lists so students can complete Assignment Sheet 1. Order extra catalogs as needed.
- Add additional job sheets if needed for other hand tools, power tools, and shop equipment available in your class/shop that were not covered in this unit.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheet. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Suggested Activities

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper.* Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair*, 3rd edition. Upper Saddle River, NJ: Prentice Hall, 1994.
- *Fundamentals of Service: Shop Tools.* Moline, IL: Deere and Company, 1992.
- Schultz, Erich J. *Diesel Mechanics*, 4th ed. New York: Glencoe/McGraw-Hill, 1999.

Suggested Supplemental Resources

Print Media

- *Mac Tools, Inc. Catalog*
  P.O. Box 370
  South Fayette Street
  Washington Court House, OH 43160
  1-800-MAC-TOOLS or 614-335-4115

- *Snap-on Tools Catalog*
  Snap-on Tools Corporation
  Kenosha, WS 53141-1410
  414-656-5200

- *NAPA Tools and Equipment Catalog*
  NAPA, Inc.
  P.O. Box 974
  Sausalito, CA 94966
  1-800-LET-NAPA or 415-331-2800

- *Reid Tool Catalog*
  Reid Tool Supply Company
  2265 Black Creek Road
  Muskegon, MI 49444
  800-253-0421 or 231-777-3951

- *Black and Decker Power Tool Safety: It's Your Job*

- *DeWALT Power Tool Safety: A Skill You Need on the Job*

  Both are available from:

  Local DeWALT Service Centers or call 1-800-4DeWALT

- *Hand Tool Safety*

- *Automotive Tool Safety, Parts 1 and 2*

  Both are available from:

  Local Snap-on tool representatives or call: 1-800-756-3344 to order from the national headquarters in Grand Prairie, TX.

  Note: Other tool companies may also have videotapes or wall charts that would be useful as supplemental resources for this unit. Contact local representatives for more information.

Electronic Media

- *FOS Shop Tools* set of 47 slides (FOS5105S-152). Available from:

  Deere & Company
  Distribution Service Center
  P.O. Box 186
  Moline, IL 61266-1086

- *Shop Practices* (#0702-004), 15-minute video that covers safety guidelines for basic hand tools, power tools, and measuring devices. Available from your local Ford dealer or call:

  Ford Customer Service Division
  800-782-4356

Suggested Activities

Internet Sites

- http://www.mactools.com
- http//www.snapon.com
- http//www.napaonline.com
- http//www.reidtool.com
- http//www.blackanddecker.com

Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match the terms with their definitions.

1. Cutting tool
2. Equipment
3. Hammer
4. Hand tool
5. Pliers
6. Power tool
7. Puller
8. Wrench

____ a. Tool used to help disassemble or remove tight-fitting parts (such as pulleys and gears from shafts)

____ b. Small hand-held device operated only by manual effort for various tasks

____ c. Large implements or machines used for various operations or tasks; may be mechanically, electrically, or electronically operated

____ d. Any edged tool used to remove material from a workpiece

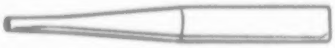
____ e. Tool used to pound or strike a blow to another object

____ f. Hand-held device operated with electrical, hydraulic, or air assistance for various tasks

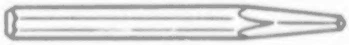
____ g. Small pinching tool used to hold small parts, bend thin metal, or cut wire

Objective 2

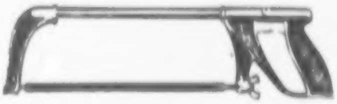
Identify the following types of cutting tools. Write your answers in the blanks provided.

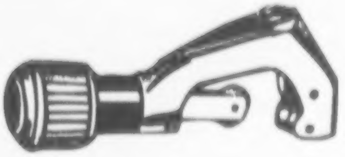


a. ______________________



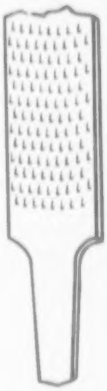
b. ______________________





c. ______________________

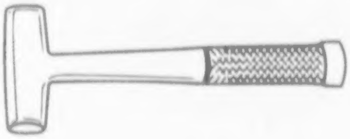
d. ______________________

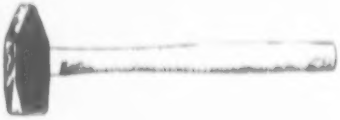


e. ______________________

Objective 3

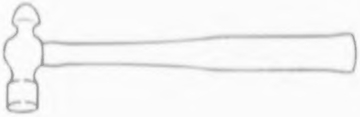
Identify the following types of hammers. Write your answers in the blanks provided.





a. ______________________

b. ______________________

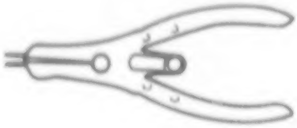


c. ______________________

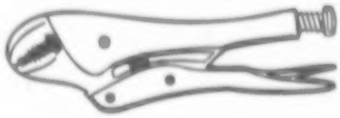
93

Objective 4

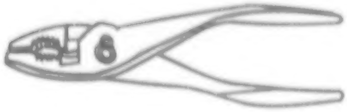
Identify the following types of pliers. Write your answers in the blanks provided.



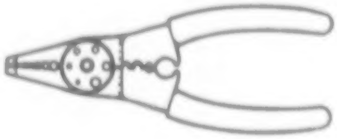
a. ____________________



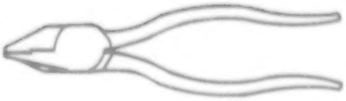
b. ____________________



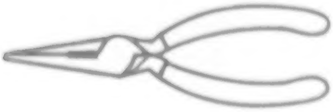
c. ____________________



d. ____________________



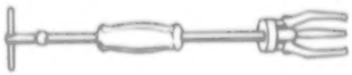
e. ____________________



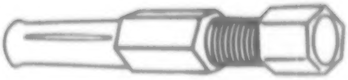
f. ____________________

Objective 5

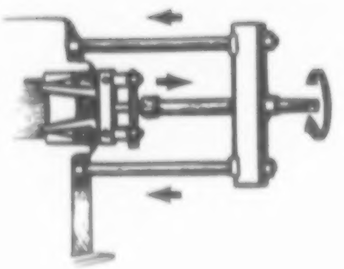
Identify the following types of pullers. Write your answers in the blanks provided.



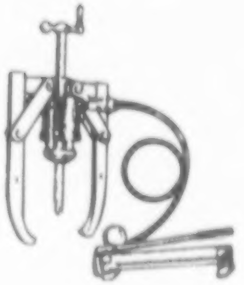
a. ____________________



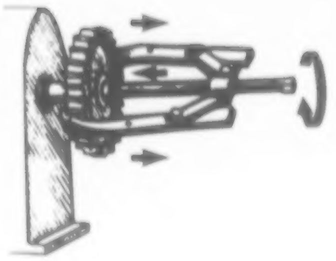
b. ____________________



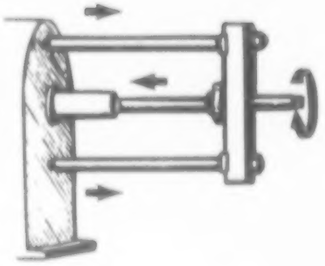
c. ______________________



d. ______________________



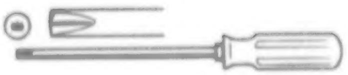
e. ______________________



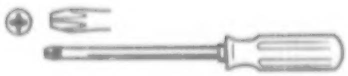
f. ______________________

Objective 6

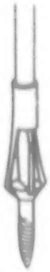
Identify the following types of screwdrivers. Write your answers in the blanks provided.



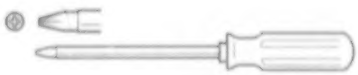
a. ______________________



b. ______________________



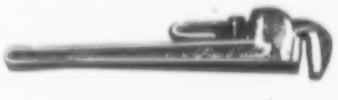
c. ______________________



d. ______________________

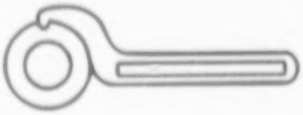
Objective 7

Identify the following types of wrenches. Write your answers in the blanks provided.

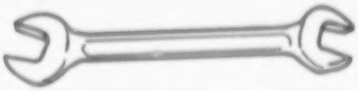


a. ______________________

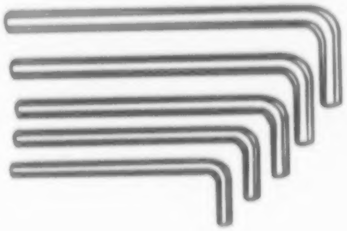
b. ______________________



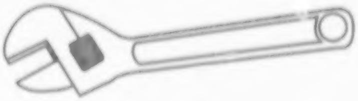
c. ______________________



d. ______________________



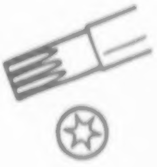
e. ______________________



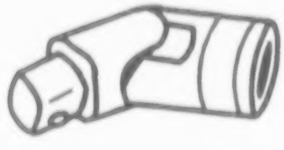
f. ______________________

Objective 8

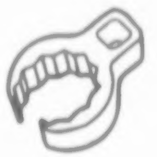
Identify the following parts of a socket wrench set. Write your answers in the blanks provided.



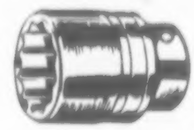
a. ______________________



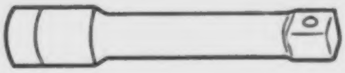
b. ______________________



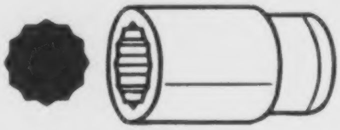
c. ______________________



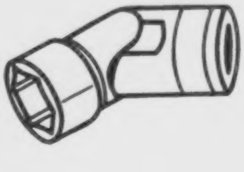
d. ______________________



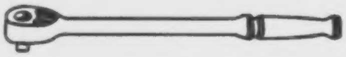
e. ____________________



f. ____________________



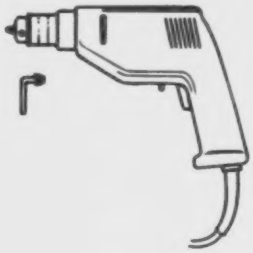
g. ____________________



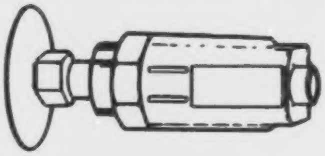
h. ____________________

Objective 9

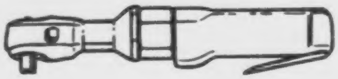
Identify the following basic power tools. Write your answers in the blanks provided.



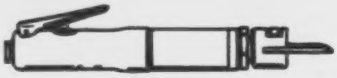
a. ____________________



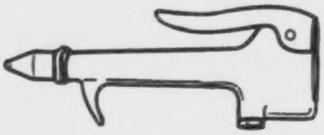
b. ____________________



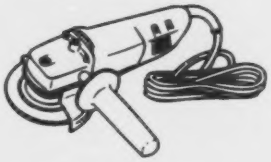
c. ____________________



d. ____________________

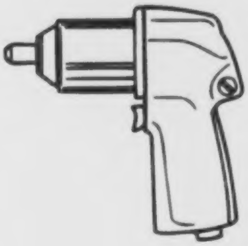


e. ____________________

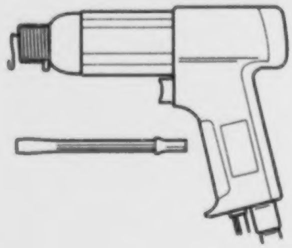


f. ____________________

97



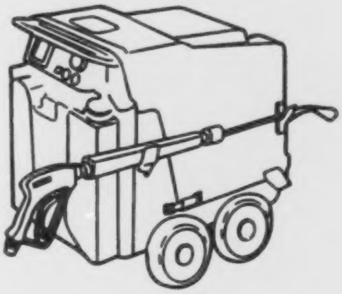
g. ______________________



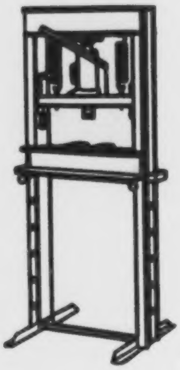
h. ______________________

Objective 10

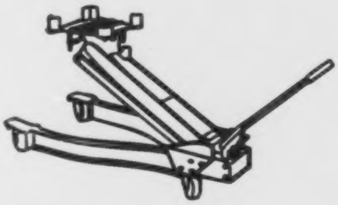
Identify the following basic shop equipment. Write your answers in the blanks provided.



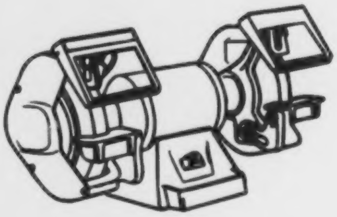
a. ______________________



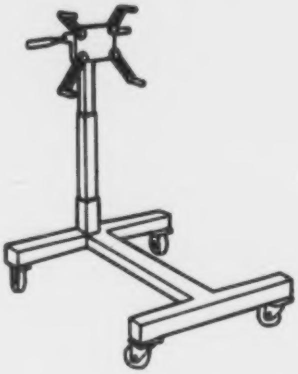
b. ______________________



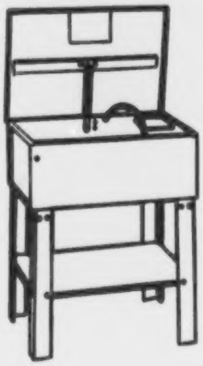
c. ______________________



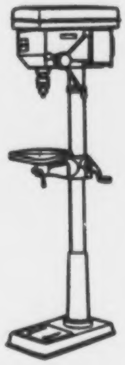
d. ______________________



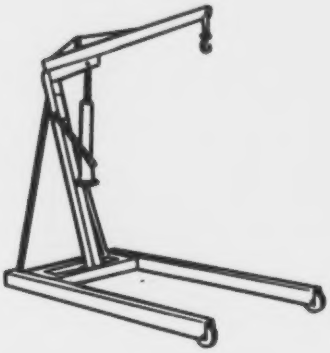
e. ______________________



f. ______________________



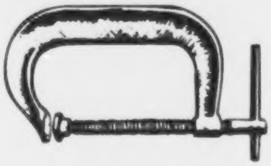
g. ______________________



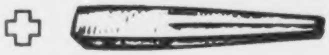
h. ______________________

Objective 11

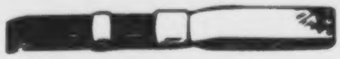
Identify the following general shop tools and equipment. Write your answers in the blanks provided.

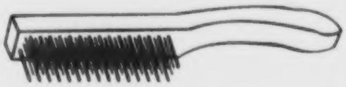


a. ______________________



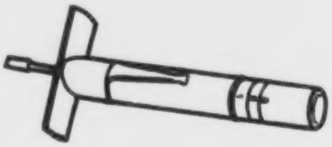
b. ______________________

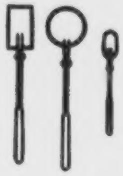




c. ______________________

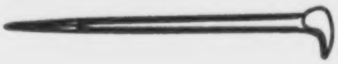
d. ______________________

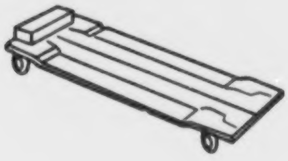




e. ______________________

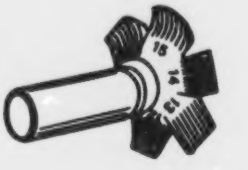
f. ______________________

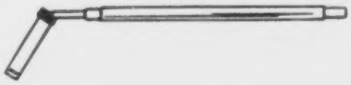




g. ______________________

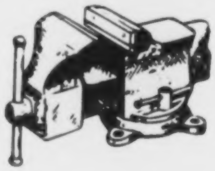
h. ______________________

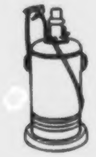




i. ______________________

j. ______________________





k. ______________________

l. ______________________

Written Test

Objective 12

Distinguish between correct and incorrect methods of using and maintaining basic hand tools by placing:

- C = next to correct methods of using and maintaining basic hand tools.
- I = next to incorrect methods of using and maintaining basic hand tools.

_____ a. When using a hacksaw, make sure that the teeth point toward the handle and that the blade is loose.

_____ b. Always hit a surface with the edge of a hammer's striking face.

_____ c. Clean a file by using a file card.

_____ d. Use pliers on the shank of a screwdriver to loosen a screw.

_____ e. Dress dull cutting edges to the original shape and 60°-65° angle.

_____ f. When using an adjustable wrench, adjust the wrench to fit the flat surfaces of the nut.

_____ g. Pliers may be used to remove damaged screws, but never use pliers to loosen nuts and bolts.

_____ h. Use a cold chisel with a mushroomed head.

_____ i. Use a bar or pipe to extend a wrench handle.

_____ j. When using an adjustable wrench, exert force against the large jaw of the wrench (so that the large jaw is opposite the direction of force).

Objective 13

Complete statements concerning safety guidelines to follow when using power tools and equipment by filling in the blanks with the correct answers.

a. Always wear your ______________________ when using power tools and equipment.

b. Remove ______________________ when operating power tools and equipment.

c. Obey all ______________________ provided by the equipment manufacturer, plus any additional ones used by your shop.

d. Keep ______________________ in place on all equipment.

e. ______________________ to the supervisor/instructor any defective tools or equipment.

f. ______________________ power equipment when not in use.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 7
b. 4
c. 2
d. 1
e. 3
f. 6
g. 5

Objective 2

a. Punch (pin punch shown)
b. Cold chisel (diamond point shown)
c. Hacksaw
d. Tubing cutter
e. File (rasp cut file shown)

Objective 3

a. Dead blow soft-face hammer (mallet)
b. Hand sledge hard-face hammer
c. Ball peen hard-face hammer

Objective 4

a. External snap-ring pliers
b. Lock grip (Vise Grip®) pliers
c. Slip-joint pliers
d. Electrical pliers or crimper/stripper
e. Side cutters
f. Needle-nose (long-nosed) pliers

Objective 5

a. Slide hammer puller
b. Blind hole puller
c. Internal puller
d. Hydraulic puller
e. External puller
f. Press type puller

Objective 6

a. Clutch head screwdriver
b. Phillips® head screwdriver
c. Starting screwdriver
d. Pozidriv® screwdriver

Objective 7

a. Pipe wrench
b. Combination wrench
c. Fixed hook spanner
d. Open end wrench
e. Hex (Allen) wrench
f. Adjustable (Crescent®) wrench

Answers to Written Test

Objective 8

a. Special purpose Torx® socket
b. Universal joint
c. Special purpose crow foot line
d. Standard depth socket
e. Extension
f. Twelve point socket
g. Universal swivel/flex socket
h. Ratchet handle

Objective 9

a. Drill
b. Cut off saw
c. Air ratchet wrench
d. Scraper
e. Air blow gun
f. Sander/grinder
g. Air impact wrench
h. Air hammer

Objective 10

a. Steam pressure washer
b. Hydraulic press with adapter
c. Transmission jack
d. Bench grinder
e. Engine stand
f. Parts washer
g. Drill press
h. Portable hydraulic crane

Objective 11

a. C-clamp
b. Square screw extractor (easy-out)
c. Carbon scraper
d. Wire brush
e. Tire tread depth gauge
f. Inspection mirror
g. Lady foot pry bar
h. Creeper
i. Fin comb
j. Magnetic pickup tool
k. Vise
l. Pneumatic grease pump

Objective 12

a. I
b. I
c. C
d. I
e. C
f. C
g. C
h. I
i. I
j. C

Objective 13

a. Any of the following answers are correct: personal protective equipment, safety glasses/goggles, or ear plugs/muffs
b. Rings and other jewelry
c. Either or both: safety rules and/or operating instructions
d. Either or both: guards and/or safety devices
e. Tag and report
f. Turn off

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 8.

☐ 4. **Go to** Shop area and view actual tools and equipment. Compare the various types of items such as hammers, screwdriver heads, file surfaces, etc.

☐ 5. **Research** Online catalogs of tool companies such as Snap-on, NAPA, and Mac, and check prices and guarantees. This activity may be completed as part of Assignment Sheet 1.

☐ 6. **Do** Assignment Sheet 1, "Use Tool Catalogs to Determine the Cost of a Quality Hand Tool Set."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 5 through 7.

☐ 8. **Study** Information Sheet, Objectives 9 through 13.

☐ 9. **Observe** Demonstration of procedure used in completing Job Sheet 1.

☐ 10. **Do** Job Sheet 1, "Dress a Grinding Wheel."

☐ 11. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 10 and 11.

Learning Activities Sheet

☐ 12. **Observe** Demonstration of procedures used in completing Job Sheets 2 and 3.

☐ 13. **Do** Job Sheet 2, "Sharpen a Twist Drill Bit."

☐ 14. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 13 and 14.

☐ 15. **Do** Job Sheet 3, "Drill Holes With a Drill Press."

☐ 16. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 15 and 16.

☐ 17. **Observe** Demonstration of procedures used in completing Job Sheets 4 and 5.

☐ 18. **Do** Job Sheet 4, "Sharpen a Cold Chisel."

☐ 19. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 18 and 19.

☐ 20. **Do** Job Sheet 5, "Use a File."

☐ 21. **Stop** Have instructor evaluate the completed job sheet and if the evaluation is satisfactory, continue to step 22. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 20 and 21.

☐ 22. **Check** With instructor for any additional assignments to be completed.

☐ 23. **Do** Additional assignments listed below.

____

____

____

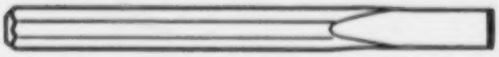
☐ 24. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 25. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

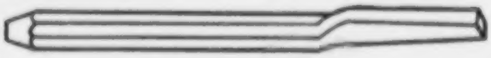
***Permission to duplicate this form is granted.**

Types of Chisels and Punches

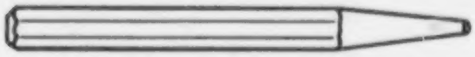
Chisels



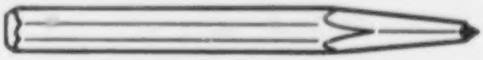
Flat chisel



Cape chisel

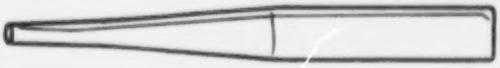


Round nose chisel

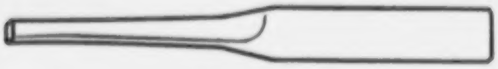


Diamond point chisel

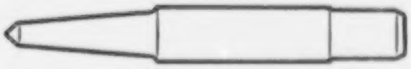
Punches



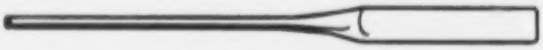
Starting punch



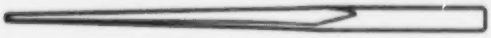
Pin punch



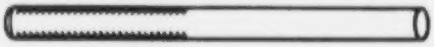
Center punch



Roll pin punch

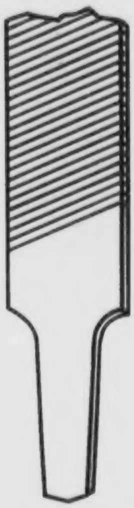


Aligning punch

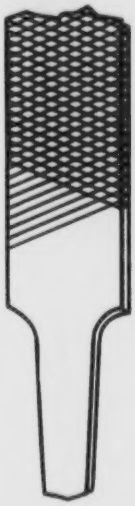


Brass punch

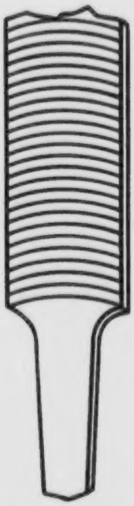
Types of Files



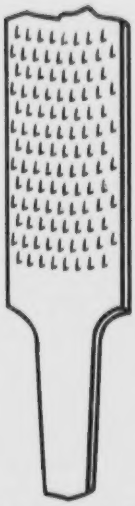
Single cut file



Double cut file



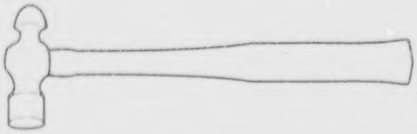
Curve tooth file



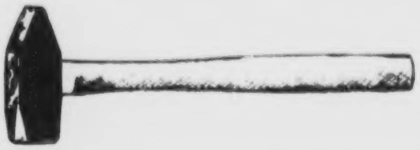
Rasp cut file

Types of Hammers

Hard-faced hammers

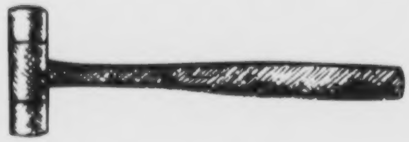


Ball peen hammer

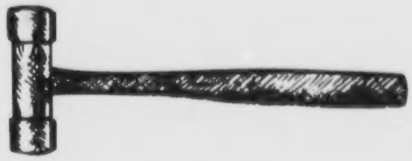


Hand sledge hammer

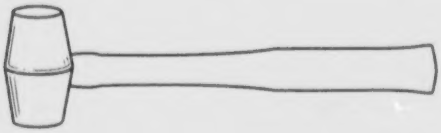
Soft-faced hammers



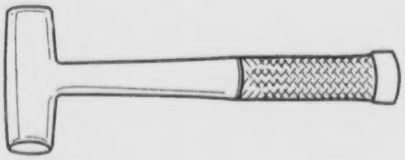
Plastic hammer



Brass hammer

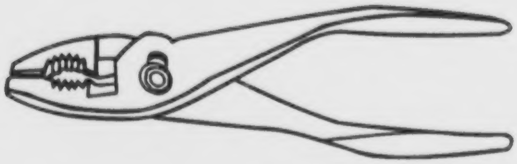


Rubber hammer

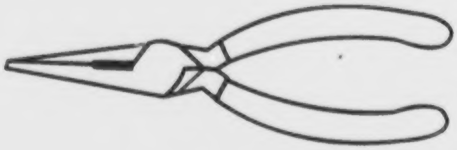


Dead blow hammer

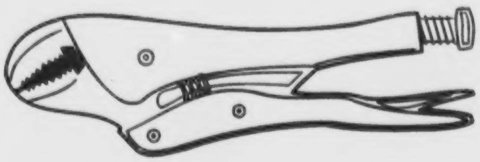
Types of Pliers



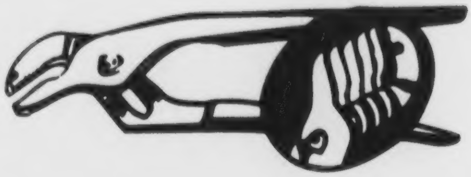
Slip joint pliers



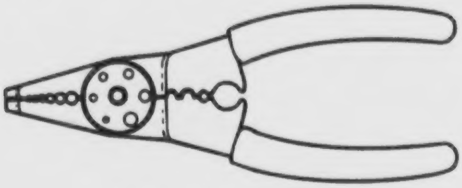
Needle nose pliers



Lock grip pliers



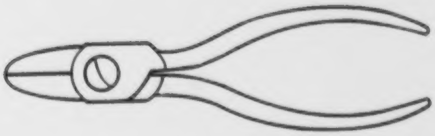
Channel lock pliers



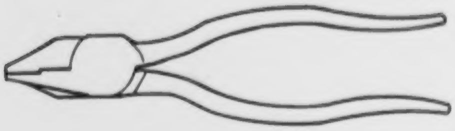
Electrical pliers

Types of Pliers

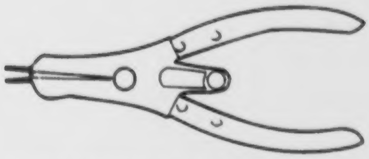
(Continued)



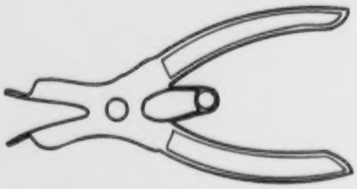
Diagonal cutters



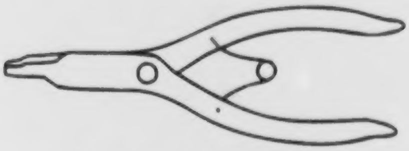
Side cutters



External/snap-ring pliers

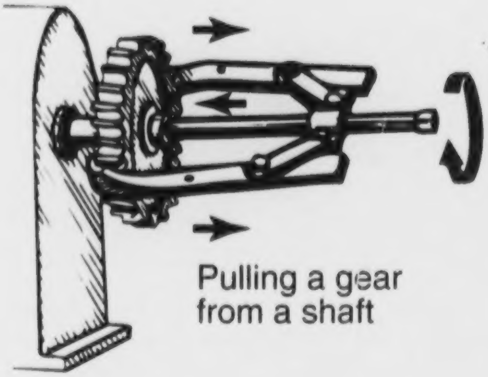


Internal/snap-ring pliers

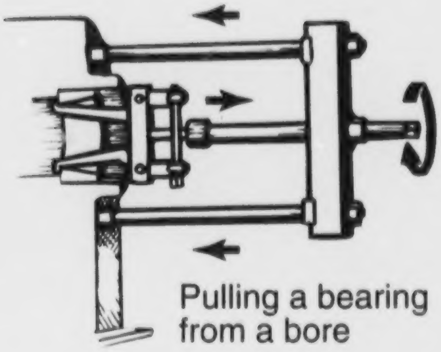


Lock ring pliers

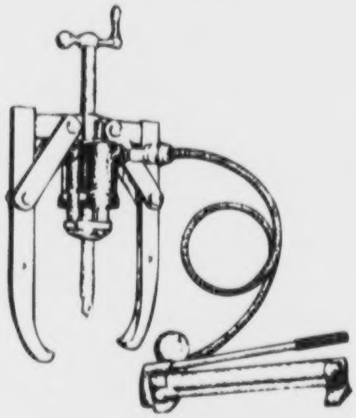
Types of Pullers

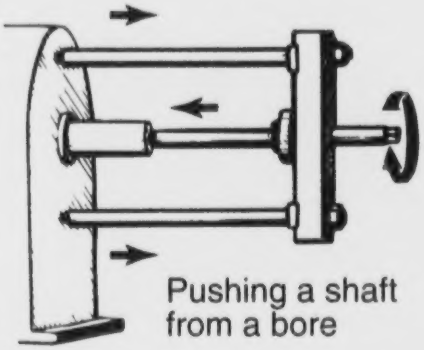

Pulling a gear from a shaft

External puller


Pulling a bearing from a bore

Internal puller

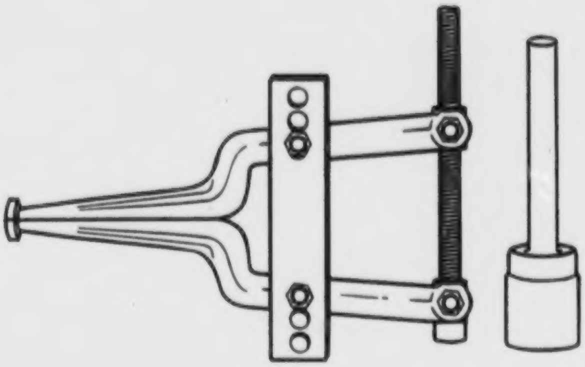

Hydraulic puller


Pushing a shaft from a bore

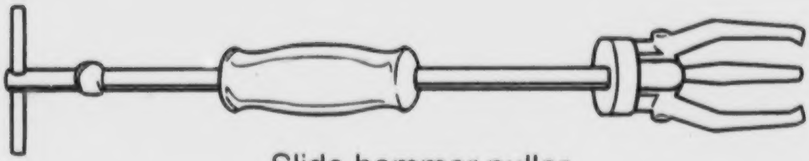
Press type puller

Types of Pullers

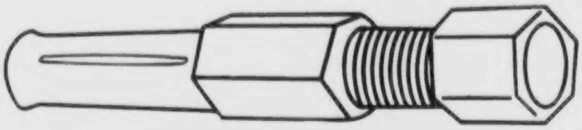
(Continued)



Seal puller

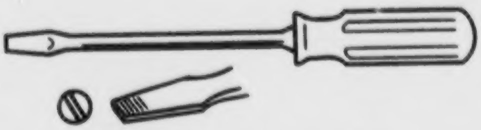


Slide hammer puller

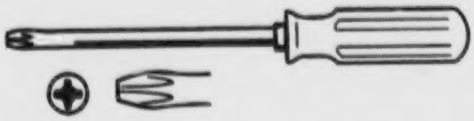


Blind hole puller

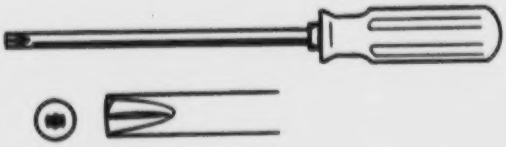
Types of Screwdrivers



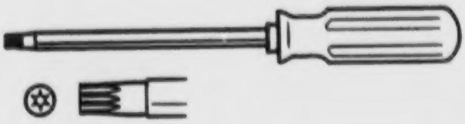
Flat blade screwdriver



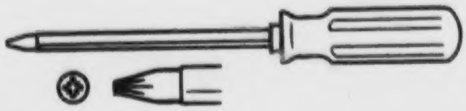
Phillips® head screwdriver



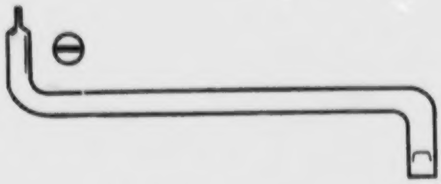
Clutch head screwdriver



Torx® screwdriver

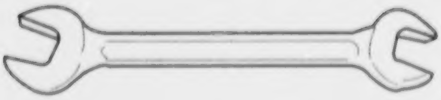


Pozidriv® screwdriver

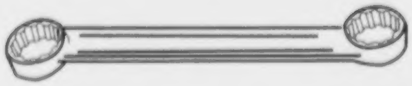


Offset screwdriver

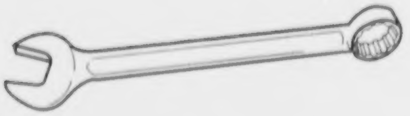
Types of Wrenches



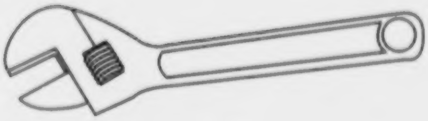
Open end wrench



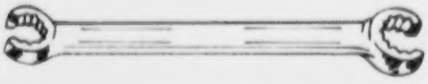
Box end wrench



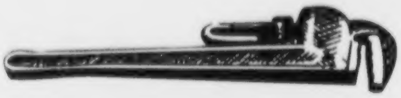
Combination wrench



Adjustable wrench



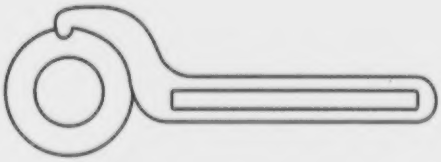
Tubing wrench



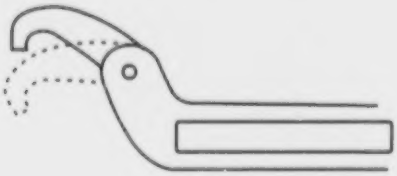
Pipe wrench

Types of Wrenches

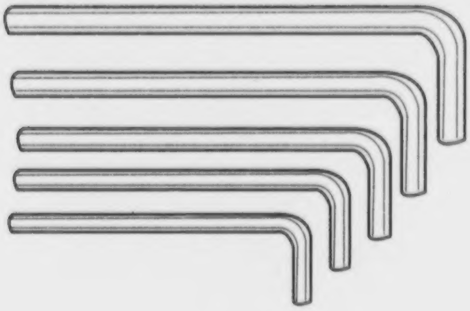
(Continued)



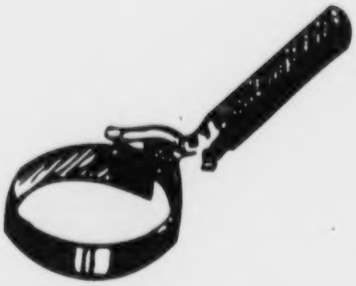
Fixed hook spanner



Adjustable hook spanner

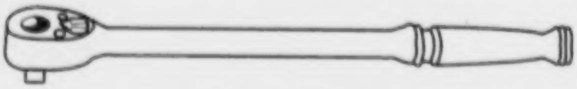


Hex key (allen) wrench

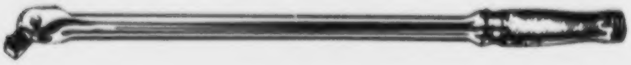


Filter wrench

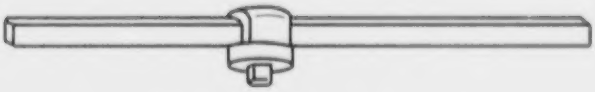
Parts of a Socket Wrench Set



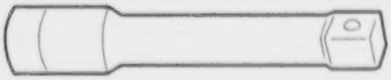
Ratchet handle



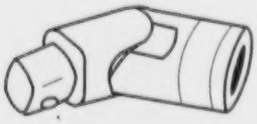
Flex handle



Sliding "T" handle



Extension

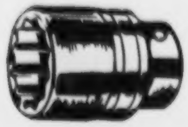


Universal joint

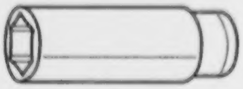
TM 11

Parts of a Socket Wrench Set

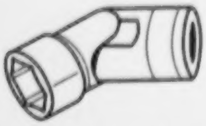
(Continued)



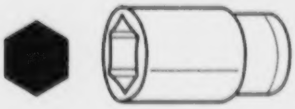
Standard depth socket



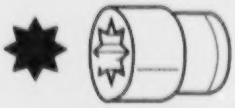
Deep well socket



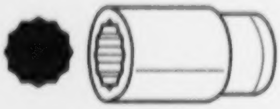
Universal swivel/flex socket



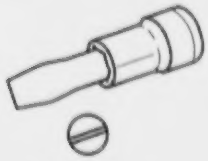
Six point socket



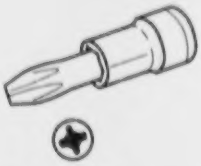
Eight point socket



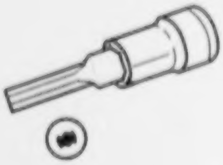
Twelve point socket



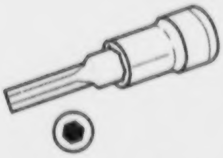
Standard socket



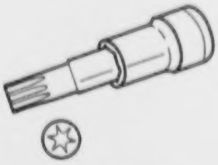
Phillips® socket



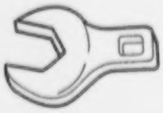
Clutch socket



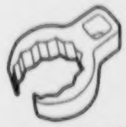
Allen or hex head socket



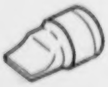
Torx® socket



Crow foot socket



Crow footline socket



Drag link socket

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 3A-3

Answers to Assignment Sheets 3A-7

Written Test 3A-9

Answers to Written Test 3A-15

Learning Activities Sheet 3A-17

Transparency Master

1—Parts of a Table 3A-19

Student Components

Student Page

Objective Sheet 3A-3

Information Sheet 3A-5

Assignment Sheets

1—Interpret Drawings Used in Diesel Equipment Reference Materials 3A-15
2—Interpret Graphs Used in Diesel Equipment Reference Materials 3A-19
3—Interpret Diagrams Used in Diesel Equipment Reference Materials 3A-23
4—Interpret Tables Used in Diesel Equipment Reference Materials 3A-27
5—Use Reference Materials to Answer Specific Questions 3A-33

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparency from the transparency master included in this unit. This appears in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Show examples of all ten types of reference materials covered in this unit. Discuss those that are commonly used and those used less often.

- Give examples of the types of information you would be trying to find and which of the various reference materials you would use to find that information.

  Examples: How to adjust end play—*Service manual*
  How to correct a leaking wheel bearing—*Service manual* or *troubleshooting manual*
  Lubrication intervals—*Driver's manual*, *maintenance manual*, or *service manual*
  Parts numbers to order replacement parts—*Parts manual (or catalog)*

- Demonstrate the correct way to look up information in reference materials. Show how easy it is to make a mistake when reading charts with small type and lots of similar numbers.

- Point out the different types of illustrations—photographs, line drawings, graphs, flow diagrams, and tables—that appear in service manuals and other reference materials. Explain that these contain a lot of information, but they need to be read carefully for good understanding.

- The assignment sheets were designed to give students experience in reading and interpreting samples of the various illustrations that may appear in reference materials. You may also want to develop additional practical tests of these skills using reference materials in your shop/classroom and questions you make up for students to find the appropriate information. These should be basic questions covering common information found in service manuals or other reference manuals.

- Demonstrate any electronic databases or on-line services available in your shop, or take students on a field trip to a local diesel service center using these services to see the new technology available. Discuss the advantages (quicker retrieval of information, no need to store all those service manuals, etc.) vs. the disadvantages (high setup cost, computer downtime stops work, etc.).

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper.* Phoenix, AZ: Barron's Educational Series, Inc. 1993.
- Clark, Elton, et al. *Diesel Fundamentals.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair*, 3rd edition. Upper Saddle River, NJ: Prentice Hall, 1994.
- *Eaton Fuller Transmissions: Engine Match Charts.* Form FUL-69-R5. Kalamazoo, MI: Eaton Corporation, Transmission Division, 1989.
- *Heavy Duty Truck Service Manual*, 1989-92. Chilton Book Company, 1993.
- *Introduction to Automotive Service.* Stillwater, OK: Curriculum and Instructional Material Center/Oklahoma Department of Vocational and Technical Education, 1989.
- "Know Your Cooling System." Caterpillar Publication No. SEBD0518-05. Caterpillar, Inc., 1990.
- *Medium-Heavy Duty Truck Service Manual*, 1989-92. Chilton Book Company, 1992.
- "Oil and Your Engine." Caterpillar Publication No. SEBD0640-01. Caterpillar, Inc., 1983.
- *Operation & Maintenance, D5B Track-Type Tractor.* Form No. SEBU5940. Caterpillar Tractor Company.
- *Operation and Maintenance Manual A Series Engines.* Cummins Bulletin No. 3810377-01. Columbus, IN: Cummins Engine Inc., 1988.
- Schultz, Erich J. *Diesel Mechanics*, 4th ed. New York: Glencoe/McGraw-Hill, 1999.

Suggested Activities

Suggested Supplemental Resources

Print Media

- Self-paced training modules
    a. Heavy Duty Trucks Service Publications (SDF-010)
    b. Freightliner Service Link 1.0

Those are available from:

Freightliner Corporation
Technical Training Department
5169 N. Lagoon Avenue
Portland, OR 97217

Answers to Assignment Sheets

Assignment Sheet 1

Interpret Drawings Used in Diesel Equipment Reference Materials

1-1. Turbocharger, adapter, and brake
1-2. V-clamp
1-3. Turbocharger

2-1. Upper transmission shaft and flywheel clutch
2-2. Flywheel clutch
2-3. Pinion shaft

3-1. Solid
3-2. Gear
3-3. Plunger

4-1. Counterclockwise
4-2. Raises it
4-3. Lash adjuster
4-4. Exhaust cam or piston rod

Assignment Sheet 2

Interpret Graphs Used in Diesel Equipment Reference Materials

1-1. 30
1-2. 5W-30
1-3. 20W-40

2-1. –15° to –20°F
2-2. 67.5 percent
2-3. 35 percent

3-1. Brand A
3-2. 75 lbs. per cu./ft.

4-1. 25 percent
4-2. 75 percent

Assignment Sheet 3

Interpret Diagrams Used in Diesel Equipment Reference Materials

1-1. Regulator, ammeter, and alternator
1-2. Alternator and battery

2-1. Through the air cleaner
2-2. In the compressor wheel section of the turbocharger
2-3. Through the crossover pipe to the intercooler
2-4. Into the turbine wheel and then to exhaust

3–1. Intake air leaks between turbocharger and cylinder head
3–2. Check exhaust manifold, muffler, and exhaust stack for restriction. Remove restrictions as necessary.
3–3. Examine the turbocharger wastegate.
3–4. Remove intake and exhaust piping, inspect shaft and wheel, and replace turbocharger if damaged.

Assignment Sheet 4

Interpret Tables Used in Diesel Equipment Reference Materials

1–1. 65
1–2. 34
1–3. 6
1–4. 2.05

2–1. 9L6933
2–2. "UP"
2–3. Oil control ring (3)
2–4. Keystone piston ring groove gauge
2–5. .0225 ± .0075 in.

3–1. 105032
3–2. Orange
3–3. Torque converter
3–4. 1
3–5. Black

4–1. Every 50 service hours or weekly
4–2. CD
4–3. Lubricate fitting
4–4. Clean and oil
4–5. Page 126
4–6. Every 250 service hours or monthly

Assignment Sheet 5

Use Reference Materials to Answer Specific Questions

Student performance should be evaluated according to the stated criteria as appropriate for the assigned engine or piece of equipment.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. After-market vendor
2. Diagram
3. Graph
4. Illustrations
5. Make of equipment
6. Model number
7. On-line reference
8. Original equipment manufacturer (OEM)
9. Reference materials
10. Specifications

_____ a. Measurements and features that apply to a specific type and model of equipment

_____ b. Drawings, photographs, diagrams, and other graphics used to clarify information contained in reference materials

_____ c. Computerized database system that allows parts and service personnel to access parts and service information directly from an OEM or after-market source in real-time

_____ d. Special type of illustration that explains rather than represents; generally used to show flow of a substance, energy through a system, or logical order of a process

_____ e. Company that supplies parts or components used to service a vehicle or piece of equipment

_____ f. Identification of equipment according to its manufacturer and associated brand names

_____ g. Books, pamphlets, videotapes, CD-ROMs, on-line information, microfilms, microfiche, and other materials used by diesel service technicians as sources of information in servicing equipment

_____ h. Special type of illustration used to show the relationship between two or more quantities (or variables)

_____ i. Company that manufactures and sells the final end product such as tractor-trailer, construction equipment, or agricultural equipment

_____ j. Numerical designation used to identify an equipment design, usually coded to indicate specifications

Objective 2

Match the types of reference materials with their descriptions.

1. After-market service manual
2. Diagnostic or troubleshooting manual
3. Government publications
4. Maintenance manual
5. OEM service manual
6. Owner's/driver's manual
7. Parts bulletin
8. Parts manual
9. Service bulletin
10. Service products/ tools catalog

_____ a. Outline federal and state safety and environmental procedures and requirements

_____ b. Developed by an equipment manufacturer for a particular piece of equipment

_____ c. Identifies specially-designed products or tools needed to perform particular equipment maintenance and repair tasks

_____ d. Used to identify equipment parts, generally through the use of parts drawings and lists

_____ e. Issued by an OEM on a frequent or regular basis to update or clarify service manuals or to alert service personnel to a special or new procedure

_____ f. Gives detailed information on daily and periodic inspections, specific maintenance procedures, change intervals, and lubrication charts

_____ g. Developed by an agency other than the equipment manufacturer for a variety of engines and/or equipment

_____ h. Provides service personnel with detailed instructions and specifications for troubleshooting, maintaining, and repairing system components

Objective 3

Distinguish between types of illustrations used in reference materials by placing:

- D = next to drawings
- P = next to photographs

_____ a. Taken by a camera to show an actual part or a step in a procedure

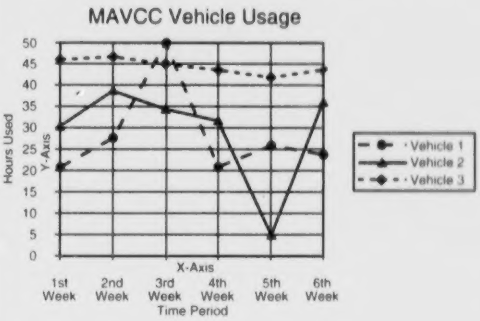
_____ b. May be pictorial (picture-like), sectional (cutaways), or detailed (closeups)

_____ c. May include part numbers or letters as callouts to simplify the illustration

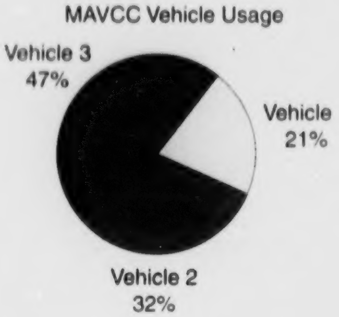
_____ d. Used to convey more detailed and more complex information

Objective 4

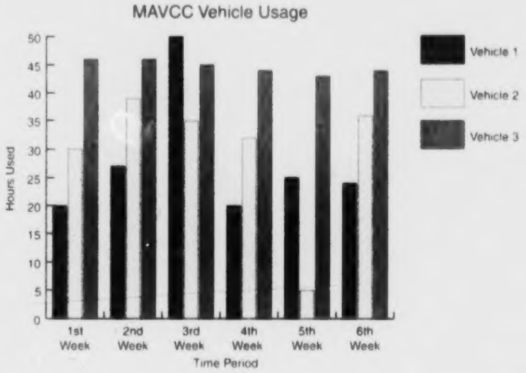
Identify types of graphs used in reference materials.



a. ______________________



b. ________________

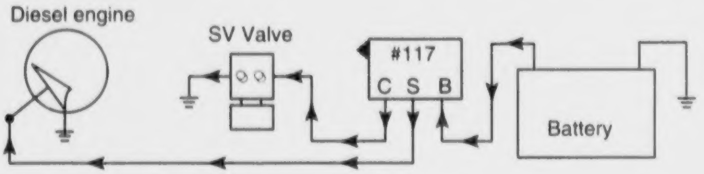


c. ______________________

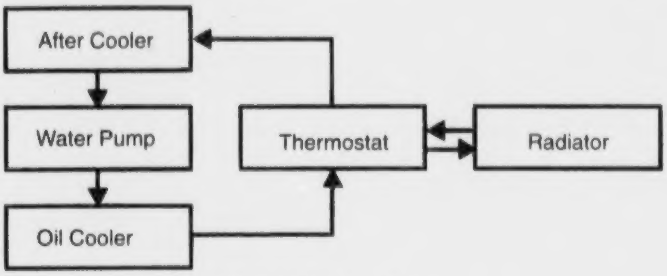
Written Test

Objective 5

Identify types of diagrams used in reference materials. Write your answers in the blanks provided.


Diesel engine
SV Valve
#117
C S B
Battery

a. ______________________


After Cooler
Water Pump
Oil Cooler
Thermostat
Radiator

Diesel Engine Cooling System

b. ______________________

Objective 6

Identify the parts of a reference table. Write your answers in the blanks provided.

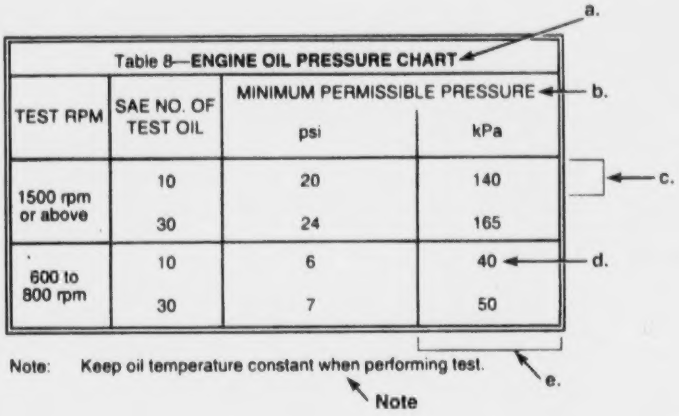


Table 8—ENGINE OIL PRESSURE CHART

TEST RPM	SAE NO. OF TEST OIL	MINIMUM PERMISSIBLE PRESSURE psi	MINIMUM PERMISSIBLE PRESSURE kPa
1500 rpm or above	10	20	140
	30	24	165
600 to 800 rpm	10	6	40
	30	7	50

Note: Keep oil temperature constant when performing test.

a. ______________________ b. ______________________

c. ______________________ d. ______________________

e. ______________________

Objective 7

Match the types of tables used in reference materials with their descriptions.

1. Application table
2. Problem-remedy table
3. Specification table

_____ a. Lists problems and symptoms, their probable causes, and recommended repair or maintenance procedures that should correct or remedy the problems

_____ b. Generally lists common factors (such as models of equipment, operating hours, or service procedures) as the column headings and then marks the applicable boxes in that column with a symbol such as an X or a check mark

_____ c. Used to provide specifications for operation, service, and overhaul of a specific make and model of equipment

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 10
b. 4
c. 7
d. 2
e. 1
f. 5
g. 9
h. 3
i. 8
j. 6

Objective 2

a. 3
b. 6
c. 10
d. 8
e. 9
f. 4
g. 1
h. 5

Objective 3

a. P
b. D
c. P or D
d. D

Objective 4

a. Line graph
b. Circle graph (or pie chart)
c. Bar graph

Objective 5

a. Schematic diagram
b. Block diagram

Objective 6

a. Title or name of table
b. Headings
c. Rows
d. Entry
e. Column

Objective 7

a. 2
b. 1
c. 3

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 3.

☐ 4. **Do** Assignment Sheet 1, "Interpret Drawings Used in Diesel Equipment Reference Materials."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat steps 3 through 5.

☐ 6. **Research** Online resources for examples of illustrations used in diesel equipment reference/service manuals.

☐ 7. **Study** Information Sheet, Objective 4.

☐ 8. **Do** Assignment Sheet 2, "Interpret Graphs Used in Diesel Equipment Reference Materials."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, repeat steps 7 through 9.

☐ 10. **Study** Information Sheet, Objective 5.

☐ 11. **Do** Assignment Sheet 3, "Interpret Diagrams Used in Diesel Equipment Reference Materials.."

Learning Activities Sheet

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, repeat steps 10 through 12.

☐ 13. **Study** Information Sheet, Objectives 6 and 7.

☐ 14. **Do** Assignment Sheet 4, "Interpret Tables Used in Diesel Equipment Reference Materials."

☐ 15. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, repeat steps 13 through 15.

☐ 16. **Do** Assignment Sheet 5, "Use Reference Materials to Answer Specific Questions."

☐ 17. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, repeat steps 16 and 17.

☐ 18. **Check** With instructor for any additional assignments to be completed.

☐ 19. **Do** Additional assignments listed below.

____

____

____

☐ 20. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 21. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Parts of a Table

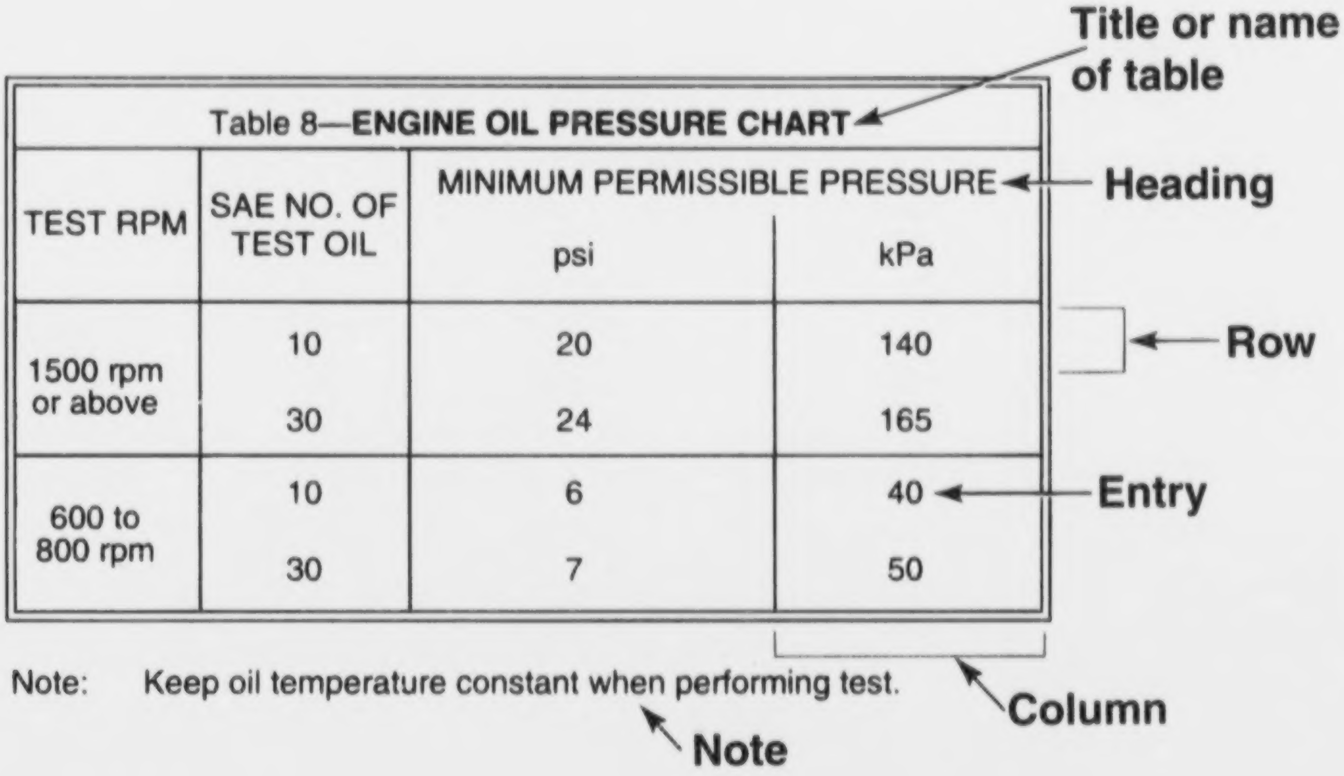


Table 8—**ENGINE OIL PRESSURE CHART**

TEST RPM	SAE NO. OF TEST OIL	MINIMUM PERMISSIBLE PRESSURE	
		psi	kPa
1500 rpm or above	10	20	140
	30	24	165
600 to 800 rpm	10	6	40
	30	7	50

Note: Keep oil temperature constant when performing test.

Title or name of table

Heading

Row

Entry

Column

Note

Unit 4-A Measuring Instruments

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 4A-3
Answers to Assignment Sheets 4A-9
Written Test 4A-13
Answers to Written Test 4A-25
Learning Activities Sheet 4A-29

Transparency Masters

1—Types of Rules 4A-33
2—Units of Measurement 4A-35
3—Types of Calipers 4A-37
4—Types of Micrometers 4A-39
5—Types of Gauges 4A-41
6—Types of Torque Wrenches 4A-43
7—Types of Feeler Gauges 4A-45
8—Instruments Used to Measure Angles 4A-47

Student Components

Student Page

Objective Sheet 4A-3
Information Sheet 4A-5

Assignment Sheets

1—Read U.S. Customary and Metric Rules 4A-25
2—Draw Lines to Specified Lengths 4A-33
3—Measure Lines Using a Steel Rule 4A-35
4—Measure Lines on Objects 4A-37
5—Measure Circle Diameters 4A-39
6—Read Standard and Metric Micrometers 4A-41

Job Sheets

1—Use a Dial Caliper 4A-47
2—Use an Outside Micrometer 4A-49
3—Use an Inside Micrometer 4A-53
4—Use Telescoping Gauges 4A-57
5—Use a Dial Indicator 4A-59
6—Check a Torque Wrench for Accuracy 4A-63
7—Use a Small Hole Gauge to Measure Valve Guide Diameter . . 4A-65
8—Use a Cylinder Bore Gauge 4A-69

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Discuss the use and care appropriate for precision measuring instruments. Demonstrate how they are used, and show how to obtain "true" readings. Also show how to check for accuracy.

- Make a display of all measuring instruments included in this unit so students can hold them, see how they operate, and see the fine details that may not show up on the given drawings. Include as many examples of the following as possible:

  a. Rules
  b. Calipers
  c. Micrometers
  d. Torque wrenches
  e. Feeler gauges
  f. Dial indicator
  g. Other gauges and instruments

- Discuss storage required for precision measuring instruments. Show students the appropriate storage area for these tools/instruments.

- Discuss which instruments would be used for various types of jobs in the shop. Give a mock demonstration of using measuring instruments for common shop operations.

- Allow time for students to practice using the various instruments available in the shop/classroom.

- Add additional problems to the Assignment Sheets as needed using actual measuring instruments to make sure students understand how to read and use the instruments covered in this unit.

- Add additional job sheets if needed for measuring instruments available in your class/shop that were not covered in this unit.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper*. Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair*, 3rd edition. Upper Saddle River, NJ: Prentice Hall, 1994.
- Rudman, Jack. *Electronic Measuring Instruments*. National Learning Corporation, 1994.
- Schultz, Erich J. *Diesel Mechanics*, 4th ed. New York: Glencoe/McGraw-Hill, 1999.

Suggested Supplemental Resources

Print Media

- *Mac Tools, Inc. Catalog*
  P.O. Box 370
  South Fayette Street
  Washington Court House, OH 43160
  614-335-4115
- *Snap-on Tools Catalog*
  Snap-on Tools Corporation
  Kenosha, WS 53141-1410
  414-656-5200
- *NAPA Tools and Equipment Catalog*
  NAPA, Inc.
  P.O. Box 974
  Sausalito, CA 94966
  415-331-2800 or 800-LET-NAPA
- *Reid Tool Catalog*
  Reid Tool Supply Company
  2265 Black Creek Road
  Muskegon, MI 49444
  800-253-0421 or 616-777-3951
- *How to Read, Use, and Care for Micrometers and Vernier Gauges*
- *The Tools and Rules for Precision Measuring*

The two items above are available from:

L.S. Starrett Company
121 Crescent Street
Athol, MA 01331
508-249-3551

- *Using the Vernier Caliper*
- *Introduction to the Outside Micrometer*
- *Measuring with Bore Gauges*
- *Working with Depth Gauges*
- *Using Dial Indicators*
- *Exploring Protractors and Gauge Blocks*
- *Powers of Ten and Metric Prefixes*

The seven items above are available as videotapes, study guides, or CD-ROMs from:

Bergwall Productions Inc.
540 Baltimore Pike
P.O. Box 2400
Chadds Ford, PA 19317-9904
800-645-3565

- An Introduction to Torque (SEBV0516), 30-page book (1989), available from your local CAT dealer or write the following for more information:

Caterpillar Service Training
600 W. Washington St., Bldg. JJ
East Peoria, IL 61630

Electronic Media

- *Metrics in the Shop.* Video or slide/cassette available from:

Robert Bosch Corporation
Training Materials
2740 West 79th Street
Chicago, IL 60652
800-937-2672

Answers to Assignment Sheets

Assignment Sheet 1

Read U.S. Customary and Metric Rules

Part A

1. a. 1/4"
   b. 1/2"
   c. 1 1/4"
   d. 1 3/4"
   e. 1 1/4"
   f. 2 1/2"
   g. 1 1/4"
   h. 2 1/2"
   i. 1 1/2"
   j. 4"

2. a. 3/8"
   b. 1/4"
   c. 1 1/8"
   d. 3/4"
   e. 1 1/2"
   f. 2 3/4"
   g. 1/2"
   h. 2"
   i. 4 1/4"
   j. 2 3/8"

3. a. 15/16"
   b. 1/2"
   c. 1 13/16"
   d. 3/4"
   e. 1 11/16"
   f. 3 5/16"
   g. 1 1/2"
   h. 2 5/8"
   i. 4 1/4"
   j. 1 5/8"

4. a. 25/32"
   b. 1 5/32"
   c. 3/8"
   d. 1 27/32"
   e. 1 9/16"
   f. 1 1/2"
   g. 1 3/16"
   h. 2 13/16"
   i. 4 9/32"
   j. 1 15/16"

Part B.

1. a. .08"
   b. .40"
   c. .58"
   d. .80"
   e. 1.28"
   f. .09"
   g. .38"
   h. .84"
   i. 1.07"
   j. 1.45"

2. a. .15"
   b. .50"
   c. 1.25"
   d. 1.80"
   e. 2.85"
   f. 3.95"
   g. 4.35"
   h. 4.95"
   i. 5.35"
   j. 5.85"

Part C

1. a. 5 mm
   b. 20 mm
   c. 37 mm
   d. 49 mm
   e. 73 mm
   f. 6.5 mm
   g. 17.5 mm
   h. 30.5 mm
   i. 50.5 mm
   j. 69.5 mm

Answers to Assignment Sheets

Assignment Sheet 2

Draw Lines to Specified Lengths

Student performance should be evaluated according to the criteria on the assignment sheet.

Assignment Sheet 3

Measure Lines Using a Steel Rule

1. a. 3 1/4
   b. 4 1/2
   c. 1
   d. 2

2. a. 4 7/8
   b. 2 1/2
   c. 3 5/8
   d. 4 1/4

3. a. 4 11/16
   b. 1 1/16
   c. 2 5/8
   d. 3 1/4

4. a. 4 29/32
   b. 3 15/32
   c. 2
   d. 4 1/16

5. a. 2 3/4
   b. 3 1/2
   c. 4 5/32
   d. 1 1/2

6. a. 3 cm
   b. 6 cm
   c. 1 cm
   d. 12 cm

7. a. 21 mm
   b. 53 mm
   c. 101 mm
   d. 12 mm

Answers to Assignment Sheets

Assignment Sheet 4

Measure Lines on Objects

Note: Answers will vary due to printing distortions. Answers were measured in thirty-seconds although students can measure in sixty-fourths.

1. a. 23/32
   b. 19/32
   c. 1/2
   d. 13/16
   e. 9/32
   f. 21/32
   g. 15/16
   h. 2 5/8

2. i. 3/32
   j. 2 1/8
   k. 21/32
   l. 2 7/8

3. m. 7/8
   n. 1/2
   o. 15/32
   p. 25/32
   q. 2 5/8

4. r. 25/32
   s. 1 21/32
   t. 13/16
   u. 13/32
   v. 13/32
   w. 13/16
   x. 2 7/32
   y. 3 1/4

Assignment Sheet 5

Measure Circle Diameters

Note: Answers will vary due to printing distortions. Answers were measured in thirty-seconds although students can measure in sixty-fourths.

1. 1 1/2
2. 3/4
3. 9/16
4. 1 11/32
5. 27/32
6. 1 1/4
7. 1 3/16
8. 1/2
9. 31/32

Answers to Assignment Sheets

Assignment Sheet 6

Read Standard and Metric Micrometers

Part A

1. 0.223"
2. 0.949"
3. 0.520"
4. 0.388"
5. 0.157"
6. 0.520"
7. 0.589"
8. 0.083"
9. 0.738"
10. 0.808"
11. 0.797"
12. 0.008"
13. 0.679"
14. 0.022"

Part B

1. 17.76 mm
2. 4.33 mm
3. 22.43 mm
4. 5.69 mm
5. 3.71 mm
6. 0.07 mm
7. 14.44 mm
8. 18.07 mm
9. 11.07 mm
10. 18.78 mm

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions.

1. Bezel
2. Caliper
3. Dial indicator
4. Digital readout
5. Gauge
6. Graduation
7. Instrument
8. Micrometer
9. Reference point
10. Rule
11. Torque

____ a. Starting point of measurement for both workpiece and rule

____ b. Any measuring device designed for precision work; may be mechanical or electrical/electronic

____ c. Turning or twisting force commonly used to measure nut tightness

____ d. Marking found on rules and scales to denote basic units of measurement

____ e. Display on an electronic device that shows measured data in numerical digits

____ f. Instrument with a graduated scale or dial for measuring or indicating quantity

____ g. Measuring instrument having two usually adjustable arms, legs, or jaws used to measure diameter or thickness

____ h. Measuring tool consisting of a strip of material marked off in units

____ i. Precise measuring instrument that consists of a spindle moved by a finely threaded screw

____ j. Precision instrument or gauge that consists of a face with marked graduations and a pointer

____ k. Rim that holds a transparent covering such as on watch, clock, or dial indicator

Written Test

Objective 2

Distinguish between basic measurement systems by placing a "U.S." next to U.S. customary units and an "M" next to metric units.

_____ a. Yard

_____ b. Liter

_____ c. Gram

_____ d. Ounce

_____ e. Centimeter

_____ f. Inch

_____ g. Meter

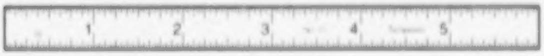
_____ h. Gallon

_____ i. Pint

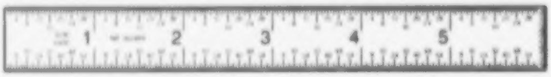
_____ j. Kilometer

Objective 3

Identify the following types of rules used by diesel technicians. Write your answers in the blanks provided.



a. ________________________________



b. ________________________________

Objective 4

Select basic units of measurement found on rules by placing an "F" next to fractional units, a "D" next to decimal units, and an "M" next to metric units.

_____ a. Tenths

_____ b. Sixty-fourths

_____ c. Decimeter

_____ d. Thirty-seconds

_____ e. Hundredths

_____ f. Centimeter

_____ g. Eighths

_____ h. Sixteenths

Objective 5

Select true statements concerning guidelines for using rules by placing a "T" next to true statements and an "F" next to false statements.

_____ a. Use the proper length and graduation.

____ b. Use largest graduation for accuracy.

____ c. Do not bend or distort a steel rule.

____ d. A steel rule may be used as a scraper if needed.

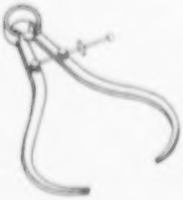
____ e. Use quarter unit graduation as reference for accuracy.

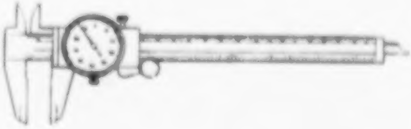
____ f. Use rule along axis parallel to plane of measurement.

____ g. Use a good quality rule.

____ h. Use rule angled on surface for better reading.

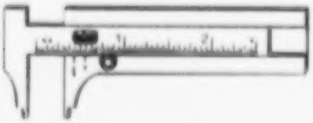
Objective 6 Identify the following types of calipers. Write your answers in the blanks provided.

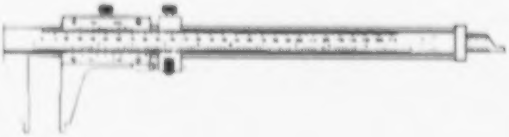




a. ______________________

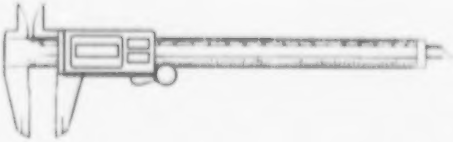
b. ______________________

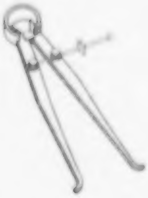




c. ______________________

d. ______________________





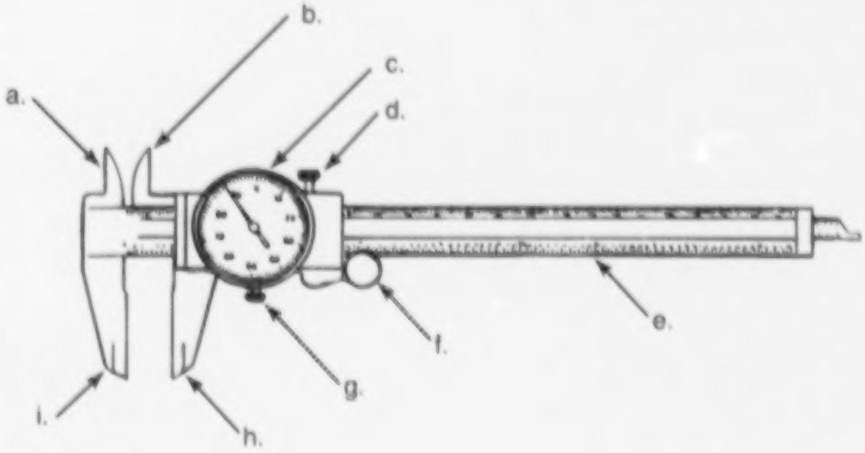
e. ______________________

f. ______________________

Written Test

Objective 7

Identify the following parts of a dial caliper. Write your answers in the blanks provided.



a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

Objective 8

Select true statements concerning guidelines for care of calipers by placing a "T" next to true statements and an "F" next to false statements.

____ a. Keep caliper free of dust, grit, and grease.

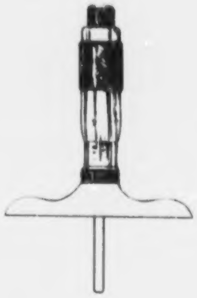
____ b. Store the caliper with other basic hand tools when it is not being used.

____ c. Clean the caliper with a shop towel and water to prevent corrosion.

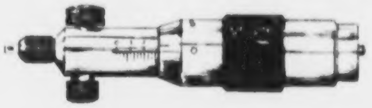
____ d. When storing, leave a gap between the fixed and movable jaws to allow for the expansion and contraction of the metal in a caliper.

Objective 9

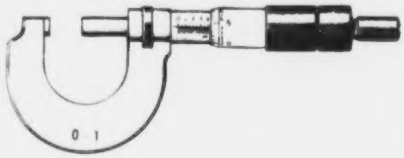
Identify the following types of micrometers. Write your answers in the blanks provided.



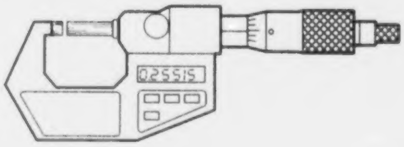
a. ______________________________



b. ______________________________



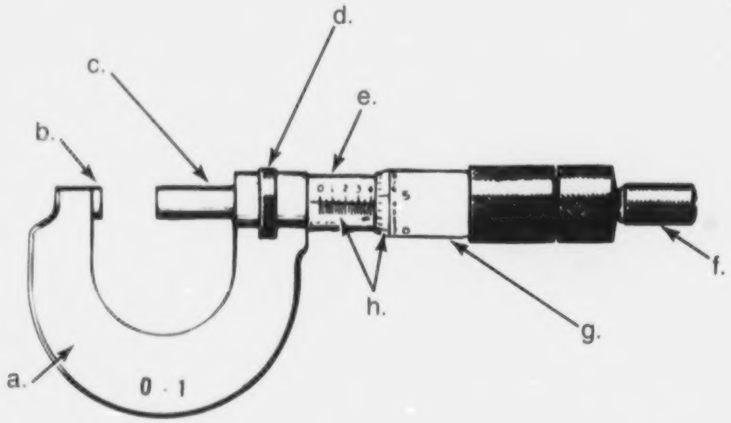
c. ______________________________



d. ______________________________

Objective 10

Identify the following parts of an outside micrometer. Write your answers in the blanks provided.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

Written Test

Objective 11

Explain how to select the proper size outside micrometer.

____

____

____

Objective 12

Select true statements concerning methods for checking accuracy of an outside micrometer by placing a "T" next to true statements and an "F" next to false statements.

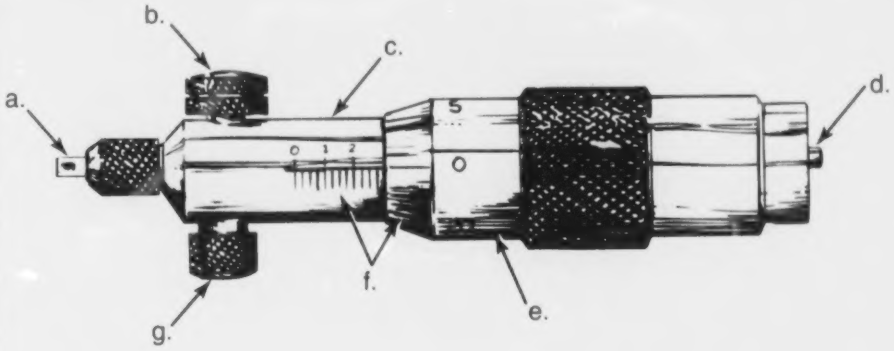
_____ a. Grease spindle and anvil surfaces.

_____ b. Observe zero references on the sleeve and thimble to make sure they line up perfectly.

_____ c. Use a standard bar or disc to check the minimum capacity.

Objective 13

Identify the following parts of an inside micrometer. Write your answers in the blanks provided.



a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

Objective 14

Match the accessories for an inside micrometer with their uses.

1. Base unit (or head)
2. Extension collar
3. Extension handle
4. Extension rods
5. Height gauge base
6. Wrench

_____ a. Used to measure in hard-to-reach places

_____ b. Used to adjust micrometer accuracy

_____ c. Extend the measuring capacity of the base unit

_____ d. Enables the micrometer to be used for inspection or setup work

_____ e. Available in various ranges of measurement

Objective 15

Select uses of an inside micrometer by placing an "X" in the appropriate blanks.

_____ a. Measure outside diameter.

_____ b. Measure width.

_____ c. Transfer measurement to machinist's inside caliper.

_____ d. Measure height.

Objective 16

Select true statements concerning methods for checking accuracy of an inside micrometer by placing a "T" next to true statements and an "F" next to false statements.

_____ a. Measure the zero reference of an inside micrometer with another inside micrometer.

_____ b. Measure an object of known accurate measurement or use a standard ring gauge.

_____ c. Use a gauge block holder and gauge blocks to check an extension bar measurement.

Objective 17

Complete statements concerning rules for use and care of micrometers by filling in the blanks with the correct answers. The statements continue on the next page.

a. Keep micrometers away from ____________________.

b. Clean the anvil and spindle/rod with a ____________________ and light machine oil to prevent corrosion.

c. Check the micrometer for accuracy against a ____________________ before use.

d. Do not ____________________ the micrometer during measurement.

e. Keep the micrometer in ____________________ when it is not being used.

f. Use micrometer only for its intended purpose as a ____________________.

Objective 18

Match the types of gauges with their uses.

1. Cylinder bore gauge
2. Dial indicator gauge
3. Small hole gauges
4. Telescoping gauges

_____ a. Used to measure small holes and to check valve guide wear; measurement is then read with outside micrometer

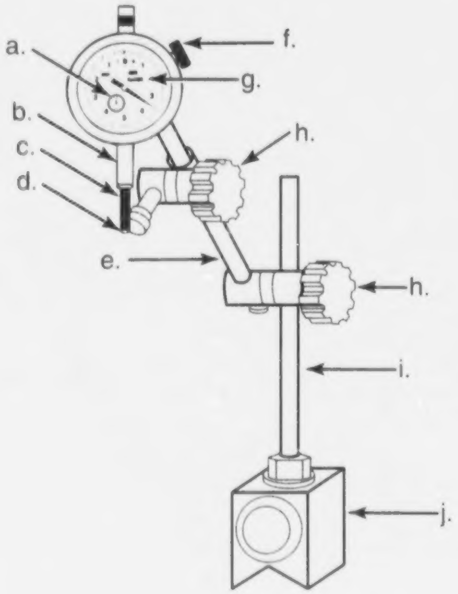
_____ b. Used to check cylinder diameter, taper, and out-of-round; measurement is registered on dial

_____ c. Used to measure the internal diameter or sizes of small cylinders, recesses, slots, and grooves; measurement is then read with outside micrometer

_____ d. Used to measure runout, roundness, and wear on various components (such as bushings, bearings, tie rod, ball joint, cam and valve guide, etc.); measurement is registered on dial

Objective 19

Identify the following parts of a dial indicator set. Write your answers in the blanks provided.



a. ____________________ f. ____________________

b. ____________________ g. ____________________

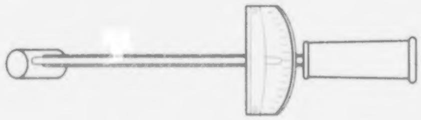
c. ____________________ h. ____________________

d. ____________________ i. ____________________

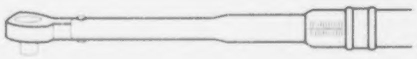
e. ____________________ j. ____________________

Objective 20

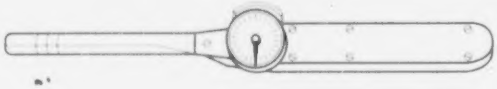
Identify the following types of torque wrenches. Write your answers in the blanks provided.



a. ____________________



b. ____________________



c. ____________________

Written Test

Objective 21

Complete statements concerning the use and care of torque wrenches by filling in the blanks with the correct answers.

a. Torque wrenches are available in various sizes of drive ends such as (list at least one size) ____________________.

b. English and/or metric systems are used on most torque wrenches which measure torque in ____________________.

c. A torque ____________________ may be used with a torque wrench for high torque applications.

d. Store torque wrenches in ____________________ when not in use.

e. If a torque wrench is dropped, check it for ____________________ before using it again.

f. Torque wrenches should be recalibrated every ____________________ or more frequently depending on use. An out-of-calibration torque wrench can cause breakage of parts or tools.

g. Frequently inspect, clean, and lubricate ratchet mechanism with ____________________.

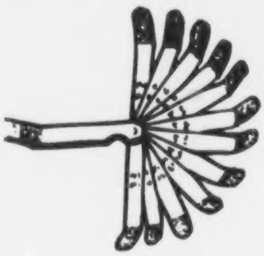
h. Do not ____________________ rated torque.

i. Do not use to break ____________________ loose.

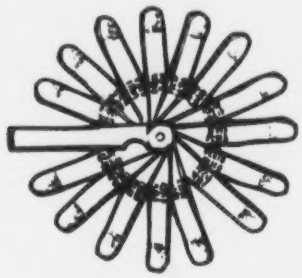
j. Do not force head of flex head against ____________________.

Objective 22

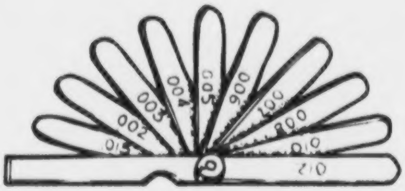
Identify the following types of feeler gauges. Write your answers in the blanks provided.



a. ____________________



b. ____________________



c. ____________________

Objective 23

Distinguish between instruments used to measure angles by placing a "P" next to the description of a protractor and an "I" next to the description of an inclinometer.

____ a. Used for making measurements of angles; graduated in 180° in both directions

____ b. Used for making precision digital measurements of angles from a horizontal axis

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 9
b. 7
c. 11
d. 6
e. 4
f. 5
g. 2
h. 10
i. 8
j. 3
k. 1

Objective 2

a. U.S.
b. M
c. M
d. U.S.
e. M
f. U.S.
g. M
h. U.S.
i. U.S.
j. M

Objective 3

a. Narrow flexible rule
b. Steel rule

Objective 4

a. D
b. F
c. M
d. F
e. D
f. M
g. F
h. F

Objective 5

a. T
b. F
c. T
d. F
e. F
f. T
g. T
h. F

Objective 6

a. Machinist's outside
b. Dial
c. Slide
d. Vernier
e. Digital readout (or electronic)
f. Machinist's inside

Objective 7

a. Inside fixed jaw
b. Inside movable jaw
c. Dial
d. Clamp screw
e. Scale
f. Roller
g. Fine adjustment nut
h. Outside movable jaw
i. Outside fixed jaw

Objective 8

a. T
b. F
c. F
d. T

Answers to Written Test

Objective 9

a. Depth
b. Inside
c. Outside
d. Digital readout (or electronic)

Objective 10

a. Frame
b. Anvil
c. Spindle
d. Lock
e. Sleeve
f. Ratchet stop
g. Thimble
h. Graduations

Objective 11

Explanation should include the following: (in the student's own words)

a. Determine the approximate size of the workpiece.
b. Observe the capacity of the outside micrometer on the frame.

Objective 12

a. F
b. T
c. T

Objective 13

a. Rod
b. Lock screw
c. Body
d. Anvil
e. Thimble
f. Graduations
g. Handle

Objective 14

a. 3
b. 6
c. 4
d. 5
e. 1

Objective 15

b, d

Objective 16

a. F
b. T
c. T

Objective 17

a. Any of the following: heat, abrasive dust, moisture, oil, or grease
b. Soft, lint-free cloth
c. Standard
d. Overtighten (or drop)
e. Either its case or box
f. Measuring instrument

Answers to Written Test

Objective 18

a. 3
b. 1
c. 4
d. 2

Objective 19

a. Revolution counter
b. Shank
c. Stem
d. Contact
e. Rod
f. Bezel clamp screw
g. Range
h. Adjustable swivel clamp
i. Post
j. Magnetic base

Objective 20

a. Beam or scale type
b. Micrometer type (click)
c. Dial type

Objective 21

a. Any of the following: 1/4", 3/8", 1/2", 3/4", or 1"
b. Any of the following: inch-pounds, foot-pounds, or Newton-meters
c. Multiplier
d. Either case or box
e. Accuracy
f. 6 months
g. Light machine oil
h. Exceed
i. Fasteners
j. Stops

Objective 22

a. Bent blades
b. Stepped or go-no-go blades
c. Flat blades

Objective 23

a. P
b. I

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 5.

☐ 4. **Do** Assignment Sheet 1, "Read U.S. Customary and Metric Rules.".

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat steps 3 through 5.

☐ 6. **Do** Assignment Sheet 2, "Draw Lines to Specified Lengths."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat steps 3, 6, and 7.

☐ 8. **Do** Assignment Sheet 3, "Measure Lines Using a Steel Rule."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, repeat steps 3, 8, and 9.

☐ 10. **Do** Assignment Sheet 4, "Measure Lines on Objects."

☐ 11. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, repeat steps 10 and 11.

Learning Activities Sheet

☐ 12. **Do** Assignment Sheet 5, "Measure Circle Diameters."

☐ 13. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, repeat steps 12 and 13.

☐ 14. **Study** Information Sheet, Objectives 6 through 8.

☐ 15. **Observe** Demonstration of procedure to be used in completing Job Sheet 1.

☐ 16. **Do** Job Sheet 1, "Use a Dial Caliper."

☐ 17. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 1 and repeat steps 14 through 17.

☐ 18. **Study** Information Sheet, Objectives 9 through 12 and Objective 17.

☐ 19. **Research** Online resources for more information about how to use common measuring instruments that are found in a diesel shop.

☐ 20. **Do** Assignment Sheet 6, "Read Standard and Metric Micrometers."

☐ 21. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 22. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 18, 20, and 21.

☐ 22. **Observe** Demonstration of procedures to be used in completing Job Sheets 2 and 3.

☐ 23. **Do** Job Sheet 2, "Use an Outside Micrometer."

☐ 24. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 25. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 23 and 24.

☐ 25. **Study** Information Sheet, Objectives 13 through 17.

☐ 26. **Do** Job Sheet 3, "Use an Inside Micrometer."

☐ 27. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 28. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 26 and 27.

☐ 28. **Study** Information Sheet, Objectives 18 through 23.

☐ 29. **Observe** Demonstration of procedure to be used in completing Job Sheet 4.

☐ 30. **Do** Job Sheet 4, "Use Telescoping Gauges."

☐ 31. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 32. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 28 through 31.

☐ 32. **Observe** Demonstration of procedure to be used in completing Job Sheet 5.

☐ 33. **Do** Job Sheet 5, "Use a Dial Indicator."

☐ 34. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 35. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 33 and 34.

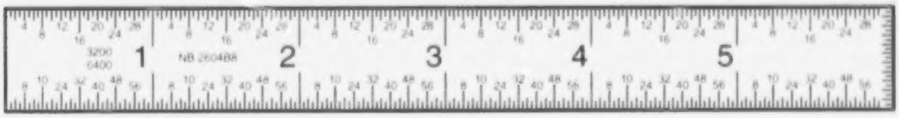
☐ 35. **Observe** Demonstration of procedure to be used in completing Job Sheet 6.

☐ 36. **Do** Job Sheet 6, "Check a Torque Wrench for Accuracy."

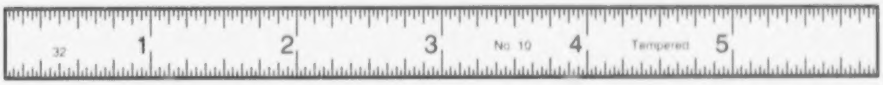
☐	37.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 38. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 36 and 37.
☐	38.	**Observe**	Demonstration of procedures to be used in completing Job Sheets 7 and 8.
☐	39.	**Do**	Job Sheet 7, "Use a Small Hole Gauge to Measure Valve Guide Diameter."
☐	40.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 41. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 39 and 40.
☐	41.	**Do**	Job Sheet 8, "Use a Cylinder Bore Gauge."
☐	42.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 43. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 41 and 42.
☐	43.	**Check**	With instructor for any additional assignments to be completed.
☐	44.	**Do**	Additional assignments listed below. ____________________ ____________________
☐	45.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
☐	46.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Types of Rules

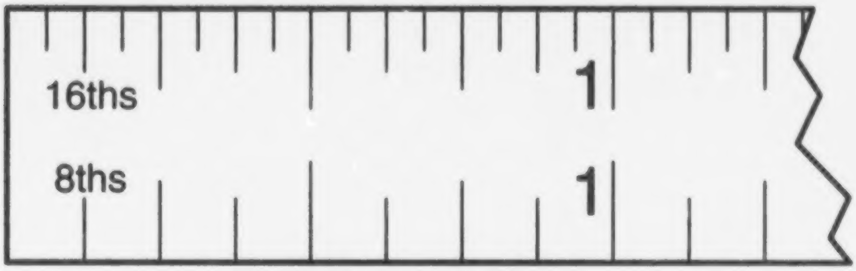

3200
6400
1
NB 260488
2
3
4
5

Steel Rule

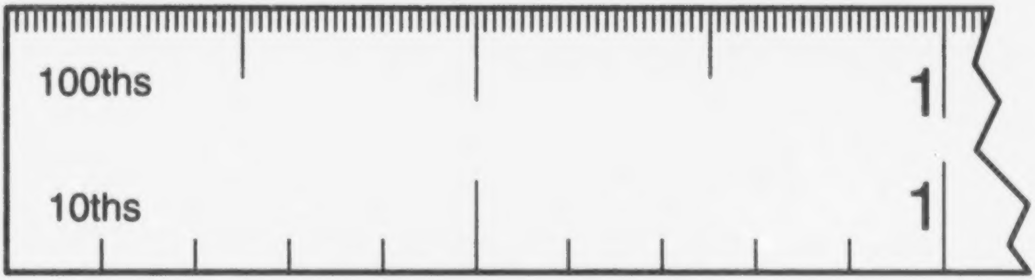

32
1
2
3
No 10
4
Tempered
5

Narrow Flexible Rule

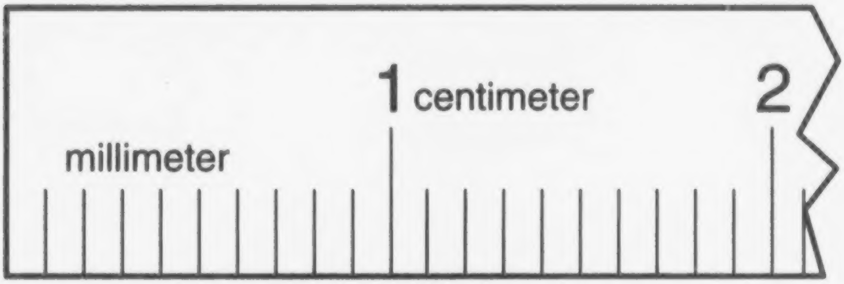
Units of Measurement


16ths
1
8ths
1

Fractional Rule


100ths
1
10ths
1

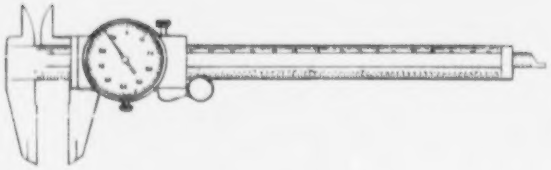
Decimal Rule


1
centimeter
2
millimeter

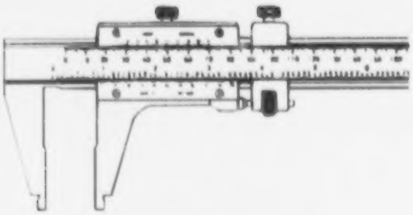
Metric Rule

TM 2

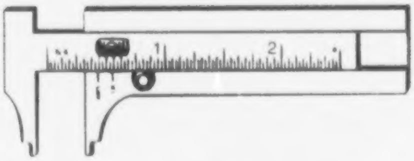
Types of Calipers



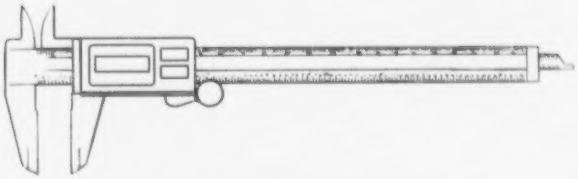
Dial



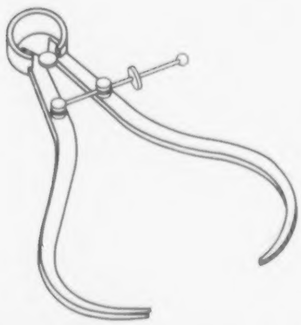
Vernier



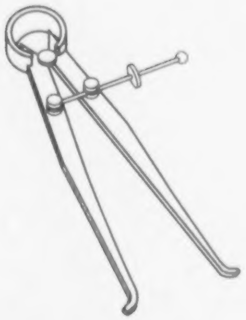
Slide



Digital Readout (Electronic)

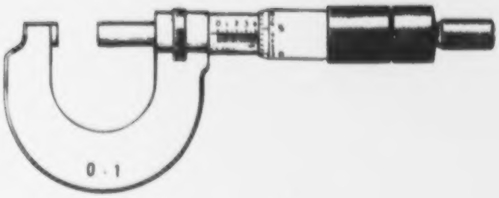


Machinist's Outside

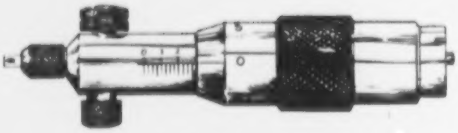


Machinist's Inside

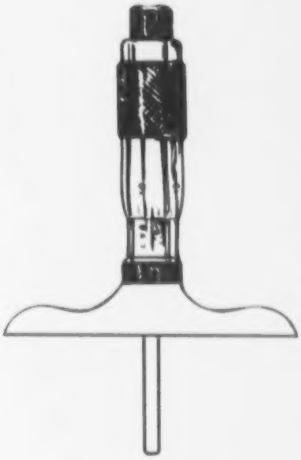
Types of Micrometers



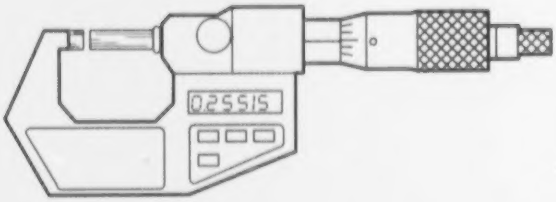
Outside



Inside

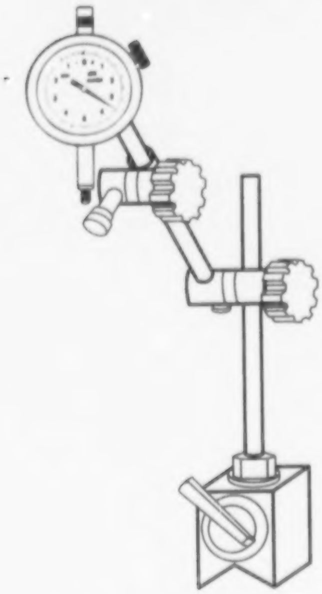


Depth

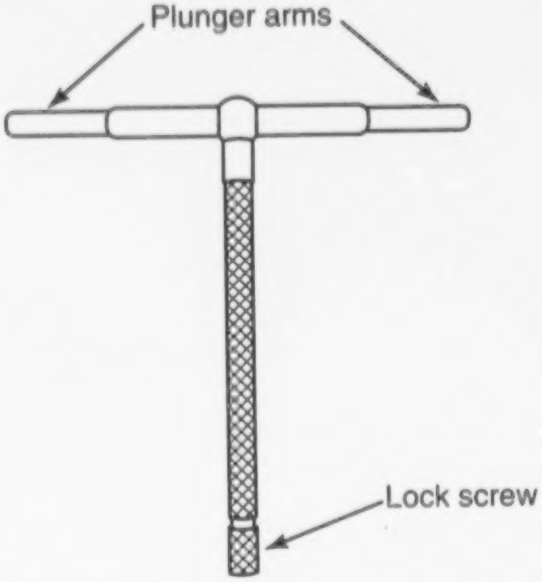


Digital Readout (Electronic)

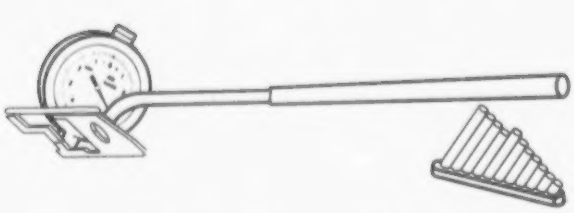
Types of Gauges



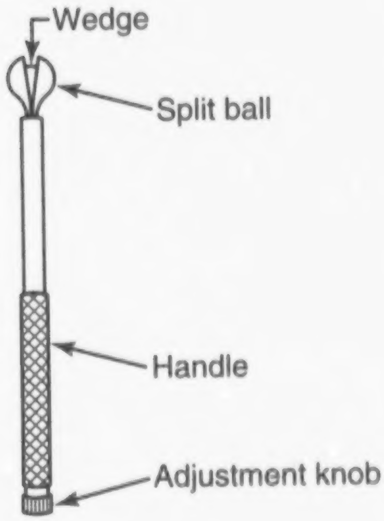
Dial Indicator


Plunger arms
Lock screw

Telescoping

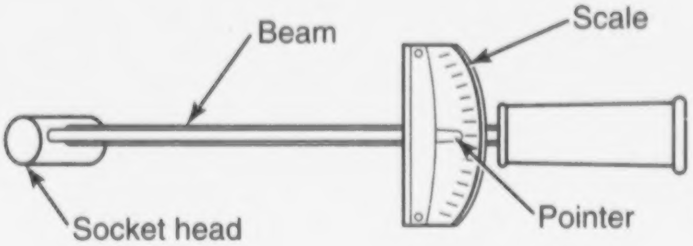


Cylinder Bore

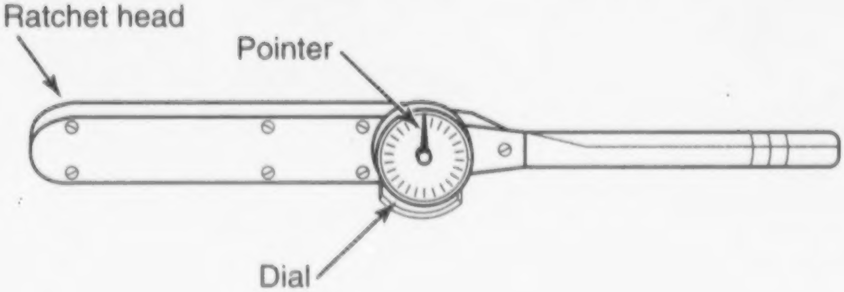

Wedge
Split ball
Handle
Adjustment knob

Small Hole

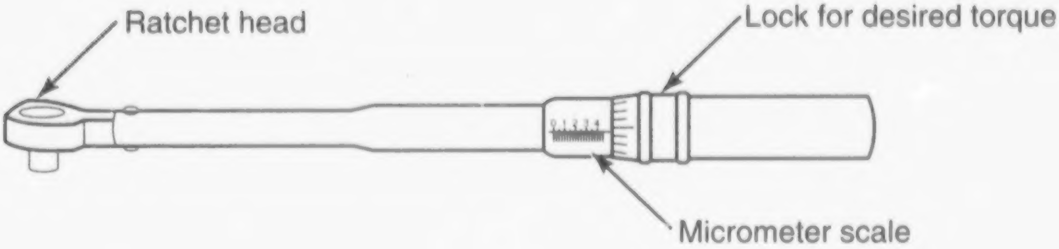
Types of Torque Wrenches


Beam
Scale
Socket head
Pointer

Beam or Scale Type

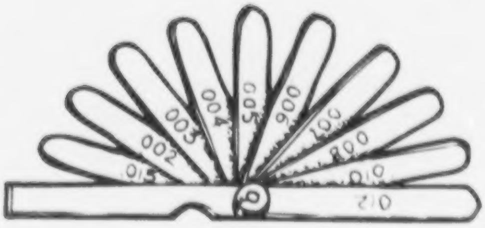

Ratchet head
Pointer
Dial

Dial Type


Ratchet head
Lock for desired torque
Micrometer scale

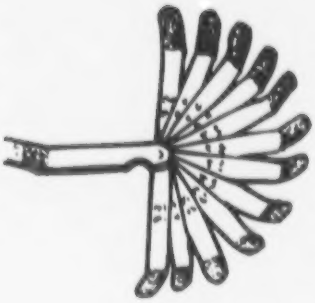
Micrometer Type (Click)

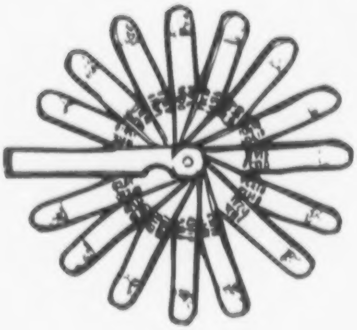
Types of Feeler Gauges

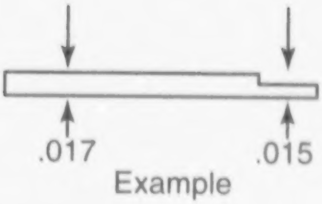

015
002
003
004
005
006
007
008
010
012

Flat Blades

Bent Blades

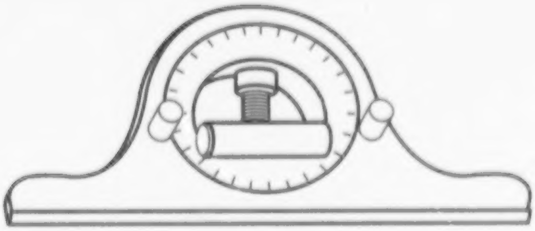




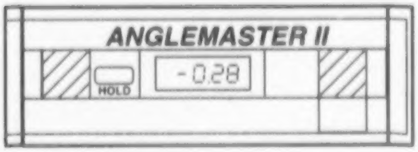

.017
.015
Example

Stepped or Go-No-Go Blades

Instruments Used to Measure Angles



Protractor


ANGLEMASTER II
HOLD
-0.28

Inclinometer

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 5A-3
Written Test 5A-9
Answers to Written Test 5A-15
Learning Activities Sheet 5A-17
Transparency Masters
  1—Example of a Job Ticket 5A-19
  2—Example of an Employee Time Card 5A-21

Student Components

Student Page

Objective Sheet 5A-3
Information Sheet 5A-5
Assignment Sheet
  1—Complete a Job Ticket 5A-13
Job Sheet
  1—Use a Computer System to Obtain Parts Information 5A-15

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of these activities.

Suggested Activities

- Discuss and demonstrate the job sheet. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of this activity and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Take students on a tour of a local diesel service shop to get an overview of how a shop operates or invite a local shop manager or owner to talk to the class about the same topic.
- Discuss (or have the speaker discuss) the amount and types of paperwork involved in running a shop. Show actual examples of the types of forms used in the shop and discuss who fills out what form.
- Emphasize the need for service centers to be competitive and profitable. Discuss how a shop can do both.
- Discuss the teamwork involved in running a shop, and discuss each person's role in the operation.
- Discuss customer service and customer satisfaction required for a profitable shop. Discuss techniques for good customer service. Refer to MAVCC's *Diesel Technology: Workplace Skills* for more information on these topics.
- Show examples of other types of job tickets (service or work orders) that may be used. Discuss the similarities and differences in filling them out.
- Show the job ticket (service or work order) that will be used in your shop and how you want it completed. Discuss whether or not you want it used for all jobs or just "live work."
- Show time clocks and time cards used in many shops and schools. Discuss how they are used and how this information is then recorded on the job ticket and/or payroll information.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheet. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheet. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper.* Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair,* 3rd edition. Upper Saddle River, NJ: Prentice Hall, 1994.
- Schultz, Erich J. *Diesel Mechanics,* 4th ed. New York: Glencoe/McGraw-Hill, 1999.

Suggested Supplemental Resources

Print Media

- *Vehicle Log Book* (TS462)—Book designed to travel with each individual vehicle, providing a running record of all maintenance and repair work. Available from your local Mack Truck service center or contact:

  Mack Trucks, Inc.
  2100 Mack Blvd.
  P.O. Box M
  Allentown, PA 18105-5000
  610-439-3011

- Self-paced training modules

  a. *Warranty: Failed Parts Tracking* (SDF-011)

  b. *Warranty: QuickClaim Process* (SDF-012)

  c. *Parts? Go Fiche!* (SDFT-800)

  a-c are available from:

  Freightliner Corporation
  Technical Training Department
  5169 N. Lagoon Avenue
  Portland, OR 97217

Electronic Media

- *A Typical Day at the Counter* (STS-1), 5-minute video
- *Making Your Inventory Work for You* (STS-2), 9-minute video
- *What is Counter Management?* (VH1-70PT), 17-minute video
- *Housekeeping Principles* (EIM-1-89), 10-minute video

The above are available from:

Dana Corporation
Publication Services
P.O. Box 453
Toledo, OH 43692-0453
419-535-4285

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions.

1. Compensation
2. Core charge
3. Employee time card
4. Expiration date
5. Job ticket
6. Obsolete
7. Rotate
8. Scrappage
9. Standard time rate tables
10. Warranty claim

_____ a. Form used to record the amount of time a wage earner spends on a job; ordinarily used with a time clock

_____ b. To organize stocked parts and materials so that older quantities are used before newer quantities

_____ c. General guidelines for the amount of time required to perform various service procedures and their approximate flat rates

_____ d. Monetary value of an employee's total pay, including wages, employer's contribution to Social Security, paid vacations and holidays, health insurance, retirement plan, or other benefits

_____ e. Deposit required on a new part until the old part is returned to the parts distributor

_____ f. Form completed to document equipment service and to record material and labor costs

_____ g. Request for reimbursement filled with an OEM or parts distributor for service work and/or parts used in a covered repair

_____ h. Parts and materials that are unusable after service procedures, usually as a result of incorrect parts usage or improper service

Written Test

Objective 2

Distinguish among basic categories of shop operation by placing:

- L = next to labor management
- P = next to parts management
- S = next to service management

_____ a. Keeping equipment service records and charging customers for material and labor costs associated with service

____ b. Selecting, ordering, stocking, issuing, and inventorying parts and materials required to support diesel equipment service

____ c. Employing and compensating workers, including labor costs for customer service charges

Objective 3

State three purposes of parts management.

a. ____

b. ____

c. ____

Objective 4

Select guidelines for maintaining good inventory control by placing an "X" in the appropriate blanks.

_____ a. Store parts so that they are physically separated from each other by part number.

____ b. Use a specific, written parts management process.

____ c. Address the specific needs of the business so that inventory levels are consistent with parts usage requirements, storage capacity, and financial status.

____ d. Document all parts transactions so that each part is accounted for.

____ e. Allow everyone to have direct access to parts.

____ f. Computerize parts management to the degree that it benefits the company.

____ g. Use only the computer for inventory control; physical inventories are unnecessary.

Objective 5

Match publications used for identifying part numbers with their descriptions.

1. Cross-reference manual
2. Parts application chart
3. Parts manual or catalog
4. Service manual

_____ a. May give part numbers during the written service procedures

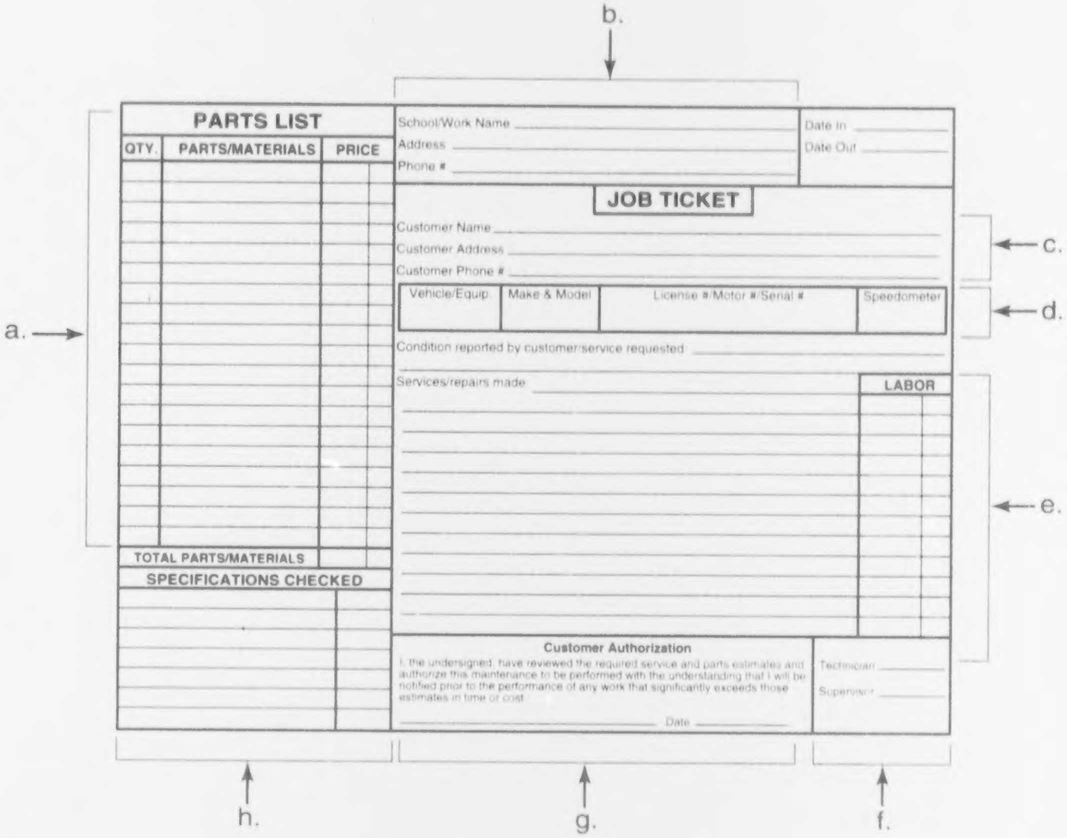
_____ b. Lists a product's intended use and generally accompanies the product

_____ c. Shows which OEM parts that a parts manufacturer's products replace; may list the part numbers of several manufacturers of a part

_____ d. Shows illustrations and part names with their associated part numbers

Written Test

Objective 6 Identify the parts of a job ticket. Write your answers in the blanks provided.



PARTS LIST

QTY. PARTS/MATERIALS PRICE

TOTAL PARTS/MATERIALS

SPECIFICATIONS CHECKED

School/Work Name
Address
Phone #

Date In
Date Out

JOB TICKET

Customer Name
Customer Address
Customer Phone #

Vehicle/Equip. | Make & Model | License #/Motor #/Serial # | Speedometer

Condition reported by customer/service requested

Services/repairs made

LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

Date

Technician
Supervisor

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

182

Written Test

Objective 7

Describe three reasons for using standard time rate tables.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

Objective 8

State two reasons for using employee time cards.

a. ______________________________

b. ______________________________

Objective 9

Complete statements concerning payroll record keeping by filling in the blanks with the correct answers.

a. An employee's payroll record begins with ______________ pay. This is the total wages or salaries before deductions.

b. Additional wages may be paid for ______________ (over 40 hours per week).

c. Payroll records are typically calculated how often? ______________

d. Mandatory withholdings include FICA (contributions to Social Security and Medicare) and ______________.

e. Optional deductions that you agree to pay for include (list one) ________

____

f. Name one mandatory contribution that your employer must make on your behalf. ______________________________

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 3
b. 7
c. 9
d. 1
e. 2
f. 5
g. 10
h. 8

Objective 2

a. S
b. P
c. L

Objective 3

Any three of the following:

a. To obtain parts and materials
b. To maintain a stock of frequently used parts and materials
c. To organize the stock so that it is maintained in a safe, orderly, readily-accessible manner
d. To rotate stock
e. To keep records of the types of parts in stock, their quantities, and their dollar value
f. To dispose of unneeded or obsolete parts and materials

Objective 4

a, b, c, d, f

Objective 5

a. 4
b. 2
c. 1
d. 3

Objective 6

a. Parts list
b. School/work identification
c. Customer identification
d. Vehicle or equipment identification
e. Description of service/repairs made and labor charges
f. Technician and supervisor signatures
g. Customer authorization
h. Specifications checked

Answers to Written Test

Objective 7

Any three of the following: (in student's own words)

a. To allow more accurate charges based on labor requirement rather than on an individual's performance or specific problems (tool availability, parts delays, etc.) encountered during the procedure
b. To provide a means of budgeting work among technicians
c. To provide a basis for estimating completion times and for giving customers estimates of costs
d. To allow technicians to check their performances against national averages
e. To simplify accounting and billing procedures
f. To calculate labor charges on warranty claims

Objective 8

Any two of the following: (in student's own words)

a. To ensure that the employee is compensated fairly for his/her time
b. To ensure that the employer receives the time on the job for which the employee is paid
c. To provide tax information as required by law
d. To assist the shop manager in evaluating and planning for personnel needs

Objective 9

a. Gross
b. Overtime
c. Weekly, bi-weekly (every other week), or monthly
d. Income taxes (state and/or federal)
e. Any one of the following:

- Medical insurance—Health (hospitalization), dental, life, and/or disability insurance for you and your family
- Retirement accounts or pension funds
- Other savings or charitable contributions—Government savings bonds, credit union savings, United Way payroll deduction, etc.

f. Any one of the following:

- FICA
- Unemployment insurance
- Worker's Compensation

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 7.

☐ 4. **Do** Assignment Sheet 1, "Complete a Job Ticket."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat steps 3 through 5.

☐ 6. **Study** Information Sheet, Objectives 8 and 9.

☐ 7. **Observe** Demonstration of procedures to be used in completing Job Sheet 1.

☐ 8. **Do** Job Sheet 1, "Use a Computer System to Obtain Parts Information."

☐ 9. **Stop** Have instructor evaluate your performance. If the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, ask your instructor to review the procedure with you, then repeat steps 8 and 9.

☐ 10. **Check** With instructor for any additional assignments to be completed.

☐ 11. **Do** Additional assignments listed below.

____

____

____

____

☐ 12. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 13. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

187

MAVCC—Diesel Technology: Introduction

Example of a Job Ticket

PARTS LIST

QTY.	PARTS/MATERIALS	PRICE	
TOTAL PARTS/MATERIALS			

SPECIFICATIONS CHECKED

School/Work Name ____________

Address ____________

Phone # ____________

Date In ____________

Date Out ____________

JOB TICKET

Customer Name ____________

Customer Address ____________

Customer Phone # ____________

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested: ____________

Services/repairs made: ____________

LABOR	

Customer Authorization

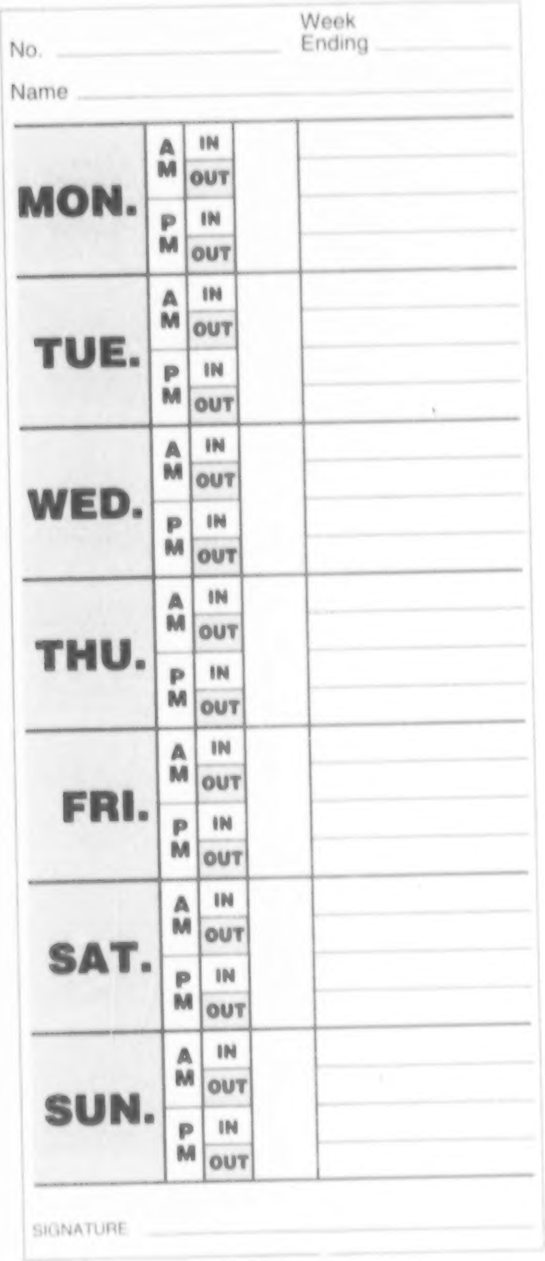
I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

____________ Date ____________

Technician ____________

Supervisor ____________

Example of an Employee Time Card



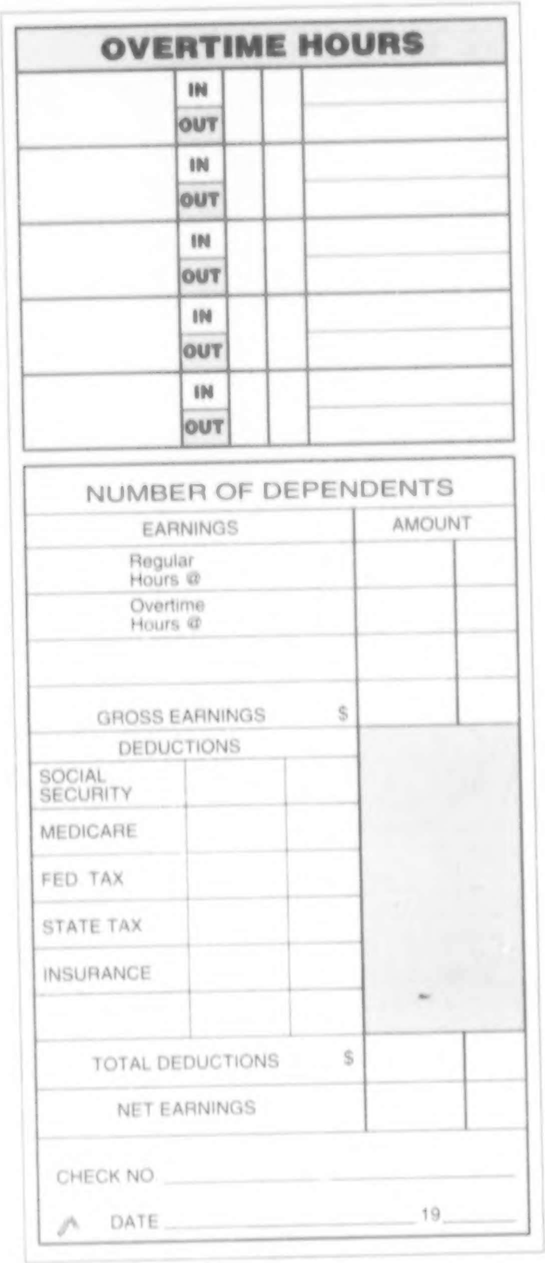
No. ______ Week Ending ______

Name ______

MON.	AM	IN		
		OUT		
	PM	IN		
		OUT		
TUE.	AM	IN		
		OUT		
	PM	IN		
		OUT		
WED.	AM	IN		
		OUT		
	PM	IN		
		OUT		
THU.	AM	IN		
		OUT		
	PM	IN		
		OUT		
FRI.	AM	IN		
		OUT		
	PM	IN		
		OUT		
SAT.	AM	IN		
		OUT		
	PM	IN		
		OUT		
SUN.	AM	IN		
		OUT		
	PM	IN		
		OUT		

SIGNATURE ______

(Front)



OVERTIME HOURS

	IN			
	OUT			
	IN			
	OUT			
	IN			
	OUT			
	IN			
	OUT			
	IN			
	OUT			

NUMBER OF DEPENDENTS

EARNINGS			AMOUNT	
Regular Hours @				
Overtime Hours @				
GROSS EARNINGS		$		
DEDUCTIONS				
SOCIAL SECURITY				
MEDICARE				
FED. TAX				
STATE TAX				
INSURANCE				
TOTAL DEDUCTIONS		$		
NET EARNINGS				

CHECK NO ______

DATE ______ 19____

(Back)

BEST COPY AVAILABLE

TM 2

T 5A–21

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 1B-3
Answers to Assignment Sheets 1B-9
Written Test 1B-11
Answers to Written Test 1B-21
Learning Activities Sheet 1B-25
Transparency Masters
1—Typical Threaded Fasteners 1B-29
2—Threaded Fastener Dimensions 1B-31
3—Typical Bolt Head Designs 1B-33
4—Typical Machine Screw Head Design 1B-35
5—Typical Nuts 1B-37
6—Typical Nuts and Bolts with Locking or Self-Locking Features 1B-39
7—Devices Used for Securing Threaded Fasteners 1B-41
8—Devices Used for Securing Threaded Fasteners (Continued) 1B-43
9—Typical Nonthreaded Fastener 1B-45
10—Typical Nonthreaded Fasteners (Continued) 1B-47
11—Tools Used to Remove Seized Threaded Fasteners 1B-49
12—Parts of a Tap and Die Set 1B-51
13—Tools Used to Restore or Replace Thread on Threaded Fasteners 1B-53
14—Types of Taps 1B-55

Student Components

Student Page

Objective Sheet 1B-3
Information Sheet 1B-5
Student Supplements
1—Wrench Sizes for Standard and Metric Threaded Fasteners 1B-27
2—Tensile Strength of Standard Grade U.S. and Metric Threaded Fasteners 1B-29

Unit Contents

Assignment Sheets

1—Measure U.S. Customary Bolts and Threads 1B–31
2—Measure Metric Bolts and Threads 1B–35
3—Match Bolts With the Correct Size Wrenches 1B–39

Job Sheets

1—Extract a Broken Bolt, Stud, or Screw 1B–41
2—Restore External Threads 1B–45
3—Cut and Restore Internal Threads 1B–47
4—Install a Thread Insert 1B–51

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Invite a local representative for a fastener manufacturer or supply distributor to talk to the class about the most common fasteners used on diesel equipment and any new fasteners on the market. Have the representative show catalogs of products, as well as samples of basic mechanical fasteners.
- Discuss the different uses of threaded vs. nonthreaded fasteners.
- Show the different sizes of standard and metric fasteners, and discuss the importance of always using the correct size tool with different sizes of fasteners.
- Have students practice measuring (sizing) different threads.
- Demonstrate the correct methods and tools to use to remove seized fasteners. Also show how some threads can be repaired.
- Show actual examples of anti-seize compounds, and discuss when they might be used.
- Have students practice cutting new threads using a tap and die set.
- Provide five U.S. customary and five metric bolts for students to measure and record in Assignment Sheets 1 and 2.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper.* Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair,* 3rd edition. Upper Saddle River, NJ: Prentice Hall, 1994.
- *Fundamentals of Service: Fasteners.* Moline, IL: Deere and Company, 1993.

- *Introduction to Automotive Service.* Stillwater, OK: Curriculum and Instructional Material Center/Oklahoma Department of Vocational and Technical Education, 1989.

Suggested Supplemental Resources

Print Media

- *Fastener Torque Manual.* Available from your local Mack Truck service center or contact:

  Mack Trucks, Inc.
  2100 Mack Blvd.
  P.O. Box M
  Allentown, PA 18105-5000
  610-439-3011

- *Fasteners* (SEBV0532), 80-page book that describes common fasteners and the tools used in their installation and removal. Available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

Electronic Media

- *Threaded Inserts* (SESV1097), 15 slides that show the procedure and tools for installing threaded inserts.

- *Taps and Retappings* (SESV1095), 19 slides that show various taps and procedure for retapping a threaded hole

  The above information is available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

- *FOS Fasteners* set of 132 slides. (FOS6004S-152) Available from:

  Deere & Company
  Distribution Service Center
  P.O. Box 186
  Moline, IL 61266-1086

- *Fastening Devices and Torquing Techniques* (#0323-112), 25-minute video and student text. Available from your local Ford dealer or call:

  Ford Customer Service Division
  800-782-4356

Answers to Assignment Sheets

Assignment Sheet 1

Measure U.S. Customary Bolts and Threads

Student performance should be evaluated according to the criteria on the assignment sheet.

Assignment Sheet 2

Measure Metric Bolts and Threads

Student performance should be evaluated according to the criteria on the assignment sheet.

Assignment Sheet 3

Match Bolts With the Correct Size Wrenches

a. 9

b. 1

c. 6

d. 5

e. 2

f. 3

g. 11

h. 10

i. 4

j. 8

k. 7

l. 15

m. 18

n. 16

o. 13

p. 17

q. 12

r. 14

Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Adhesive
2. Bolt
3. Cap screw
4. Die
5. Fastener
6. Metric
7. Nut
8. Penetrating oil
9. Rethread
10. SAE
11. Screw
12. Seized fastener
13. Self-tapping fastener
14. Stud
15. Tap
16. Tapped hole
17. Tensile strength
18. Thread
19. Threaded
20. Torque
21. U.S. customary
22. USS
23. Washer

____ a. Pointed and headed cylindrical fastener that is threaded and designed for insertion into material by rotating

____ b. To restore or replace damaged threads

____ c. Internally threaded fastener screwed onto the end of a bolt to hold objects together

____ d. Metal rod or pin that has a head at one end, a screw thread at the other end, and is secured by a nut; used for fastening objects together

____ e. Flat, thin ring used with nuts, bolts, or screws to secure a threaded fastener

____ f. Internally threaded screw cutting tool; used for forming external screw threads

____ g. Hole in which internal threads have been cut

____ h. Society of Automotive Engineers

____ i. System of measurement based on the foot, gallon, and pound

____ j. Externally threaded screw cutting tool; used for forming internal screw threads

____ k. Bolt or screw designed to cut its own threads as it is screwed into a drilled hole

____ l. Thin oil used to remove seized fasteners

____ m. Threaded fastener that is stuck and can no longer be turned, usually due to rust or corrosion

____ n. Substance such as glue or cement used to hold objects together

____ o. United States standard

____ p. Turning or twisting force that measures nut tightness

____ q. Externally threaded fastener which must be torqued by its head into a tapped hole

____ r. Having threads

____ s. Device or substance used to hold parts together

____ t. Steel rod with threads on both ends, to be screwed permanently into a fixed part at one end and receive a nut on the exposed end; usually used where aligning a bolt with a hole might be difficult

____ u. Decimal system of measurement based on the meter, liter, and gram

____ v. Raised spiral ridge of a bolt, screw, nut, or tapped hole

____ w. Amount of lengthwise force an object can withstand without pulling apart

Objective 2

Select characteristics of satisfactory fasteners from the following list by placing an "X" in the blanks next to the true statements.

_____ a. Strength

____ b. Bendability

____ c. Easily vibrated

____ d. Reusability

____ e. Difficult to remove

____ f. Durability

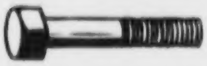
____ g. Resistance to temperature extremes

____ h. Resistance to corrosion

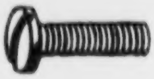
200

Objective 3

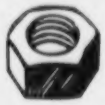
Identify typical threaded fasteners. Write your answers in the blanks provided.



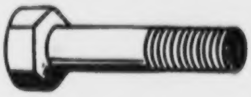
a. ____________



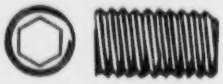
b. ____________



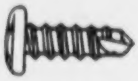
c. ____________



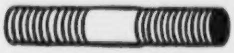
d. ____________



e. ____________



f. ____________

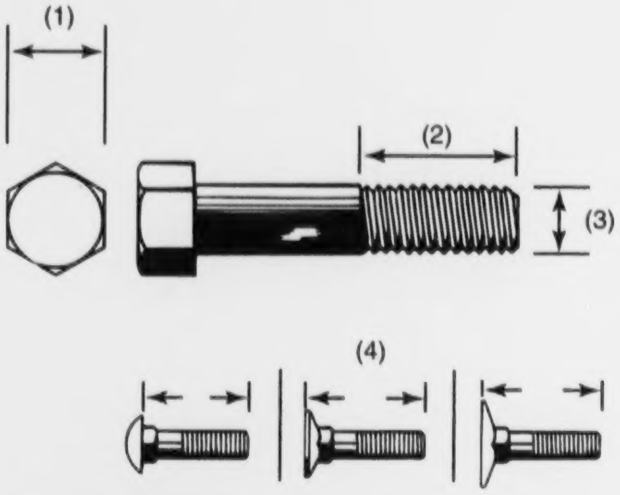


g. ____________

Objective 4

Complete the following statements concerning characteristics of threaded fasteners by circling the correct answers.

a. General dimensions



1. (Length, Wrench size)
2. (Thread length, Diameter)
3. (Length, Diameter)
4. (Thread length, Length)

b. Thread size

1. Correct thread size is critical to a threaded fastener's ability to (work properly, look good).
2. Standard thread sizes depend on the fastener's (length, diameter) and whether its threads are fine or course.
3. The size of U.S. customary threads is stated as the number of threads per (inch, diameter).
4. The size of metric threads is stated as the number of (centimeters, millimeters) between threads.
5. Tnreads should be measured with a (ruler, thread pitch gauge).

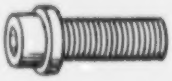
c. Grade

1. A threaded fastener's grade depends on its (tensile strength, tensile length).
2. While a threaded fastener's tensile strength is stated as its (bending point, breaking point), its grade is stated as a number.
3 The (higher, lower) the grade number, the greater the tensile strength.
4 Threaded fasteners often are marked to show their grade. Bolts and cap screws are marked on their (sides, heads).
5 U.S. customary fasteners use a system of lines or dashes in which the grade number is (two, three) greater than the number of lines.
6 U.S. customary nuts can be marked top or bottom with a similar system of dots in which (five, three) dots indicate grade five, or with a system of notches on their sides.
7 (Metric, U.S.) fasteners are simply stamped with their grade number.
8 Threaded fasteners which are not reusable should always be replaced with threaded fasteners of equal or (lower, higher) grade.

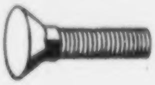
Written Test

Objective 5

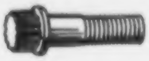
Identify typical bolt head designs. Write your answers in the blanks provided.



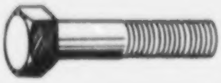
a. ____________________



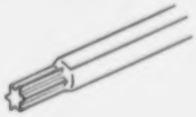
b. ____________________



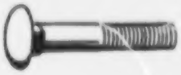
c. ____________________



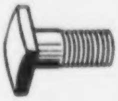
d. ____________________



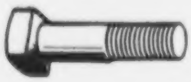
e. ____________________



f. ____________________



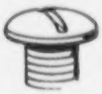
g. ____________________



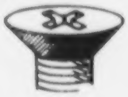
h. ____________________

Objective 6

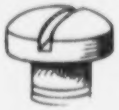
Identify typical machine screw head designs. Write your answers in the blanks provided.



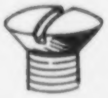
a. ____________________



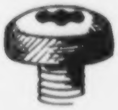
b. ____________________



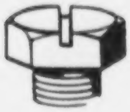
c. ____________________



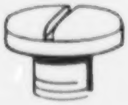
d. ____________________



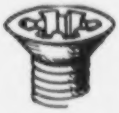
e. ____________________



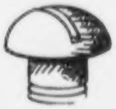
f. ____________________



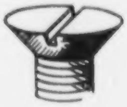
g. ____________________



h. ____________________



i. ____________________

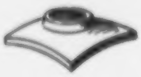


j. ____________________

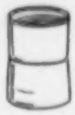
Written Test

Objective 7

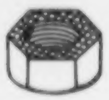
Identify typical nuts. Write your answers in the blanks provided.



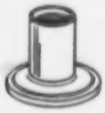
a. ____________________



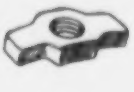
b. ____________________



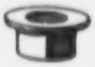
c. ____________________



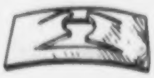
d. ____________________



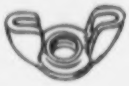
e. ____________________



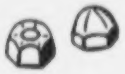
f. ____________________



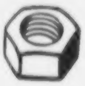
g. ____________________



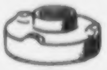
h. ____________________



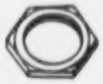
i. ____________________



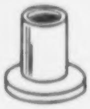
j. ____________________



k. ____________________



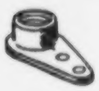
l. ____________________



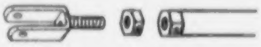
m. ____________________

Objective 8

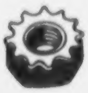
Identify typical nuts and bolts with locking or self-locking features. Write your answers in the blanks provided.



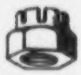
a. ____________________



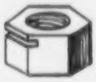
b. ____________________



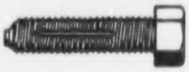
c. ____________________



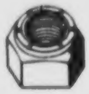
d. ____________________

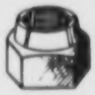


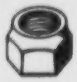
e. ____________________



f. ____________________



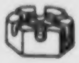




g. ____________

h. ____________

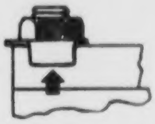
i. ____________

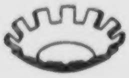


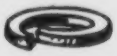
j. ____________

Objective 9

Identify devices used for securing threaded fasteners. Write your answers in the blanks provided.



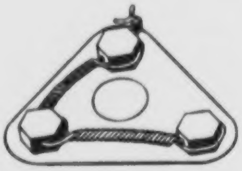


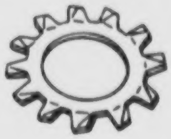


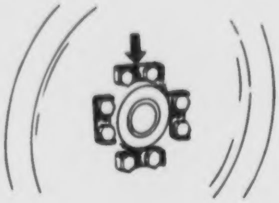
a. ____________

b. ____________

c. ____________



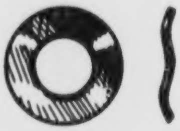


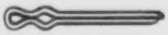


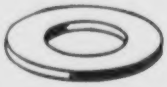
d. ____________

e. ____________

f. ____________



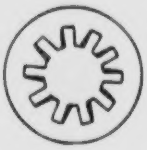


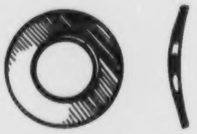


g. ____________

h. ____________

i. ____________





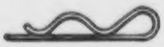
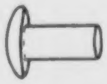
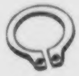
j. ____________

k. ____________

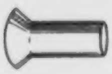
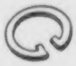
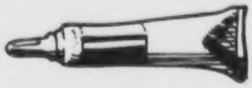
Written Test

Objective 10

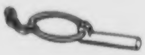
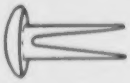
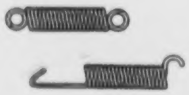
Identify typical nonthreaded fasteners. Write your answers in the blanks provided.

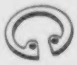
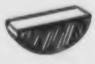
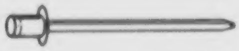
a. ____________ b. ____________ c. ____________

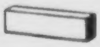
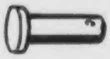
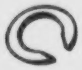
d. ____________ e. ____________ f. ____________

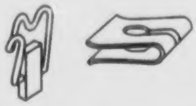
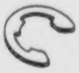
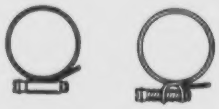
g. ____________ h. ____________ i. ____________

j. ____________ k. ____________ l. ____________

m. ____________ n. ____________ o. ____________

p. ____________ q. ____________ r. ____________

Objective 11

Select tools used to remove seized threaded fasteners by placing an "X" in the appropriate blanks.

_____ a. Pry bar

_____ b. Nut-splitter

_____ c. Drill

_____ d. Carbon scraper

_____ e. Chop saw

_____ f. Chisel

_____ g. Air wrench

_____ h. Hacksaw

Objective 12

Complete statements concerning anti-seize compounds by filling in the blanks with the correct answers.

a. Anti-seize compounds are ____________________ compounds and coatings for threaded fasteners that allow for easy removal of these fasteners from their workpieces.

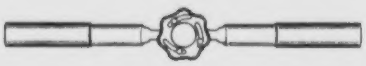
b. Anti-seize compounds prevent fasteners from ____________________ or rusting in place.

c. Graphite-based anti-seize compounds are used in applications when ____________________ is not a factor.

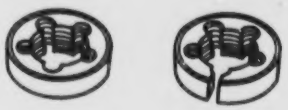
d. Graphite-based anti-seize compounds with ____________________ are used in high temperature applications where high temperature would burn away the graphite.

Objective 13

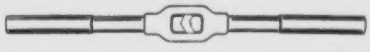
Identify parts of a tap and die set. Write your answers in the blanks provided.



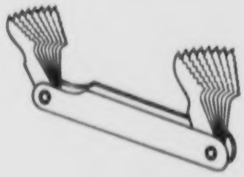
a. ____________________



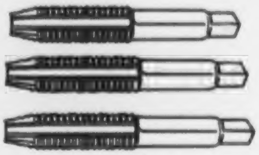
b. ____________________

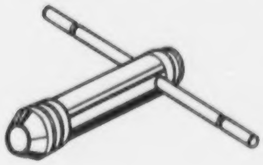


c. ____________________



d. ____________________





e. ______________________   f. ______________________

Objective 14

Distinguish among tools used to restore or replace threads on threaded fasteners by placing:

- A = next to tools used to restore external threads
- B = next to tools used to restore internal threads
- C = next to tools used to replace/repair internal threads

_____ a. Internal thread chaser

_____ b. Coiled threaded inserts

_____ c. Thread file

_____ d. Locking threaded inserts

_____ e. Rethreading tool (external chaser)

_____ f. Rethreading hand tap

_____ g. Rethreading die

Objective 15

Match the types of taps with their functions.

1. Bottoming   2. Plug   3. Taper

_____ a. Used after taper tap has cut the threads as far as possible

_____ b. Used to start the thread

_____ c. Used last to cut the thread to the bottom of the hole (if necessary)

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 11
b. 9
c. 7
d. 2
e. 23
f. 4
g. 16
h. 10
i. 21
j. 15
k. 13
l. 8
m. 12
n. 1
o. 22
p. 20
q. 3
r. 19
s. 5
t. 14
u. 6
v. 18
w. 17

Objective 2

a, d, f, g, h

Objective 3

a. Cap screw
b. Machine screw
c. Nut
d. Bolt
e. Set screw
f. Self-tapping screw
g. Stud

Objective 4

a. General dimensions

1. Wrench size
2. Thread length
3. Diameter
4. Length

b. Thread size

1. Work properly
2. Diameter
3. Inch
4. Millimeters
5. Thread pitch gauge

c. Grade

1. Tensile strength
2. Breaking point
3. Higher
4. Heads
5. Two
6. Three
7. Metric
8. Higher

Answers to Written Test

Objective 5

a. Socket head
b. Plow head
c. Twelve-point head
d. Hex head
e. External Torx® head
f. Carriage bolt
g. Askew head
h. Square head cap screw

Objective 6

a. Truss
b. Cross recessed or Phillips®
c. Fillister
d. Oval
e. Clutch
f. Hex slotted
g. Pan
h. Torx®
i. Round
j. Flat

Objective 7

a. Spring nut
b. Nutsert®
c. Serrated nut
d. T-nut or well nut
e. Specialty nut
f. Flanged nut
g. Speed nut
h. Wing nut
i Acorn nut
j. Hex nut
k. Weld nut
l. Panel nut
m. Well nut or T-nut

Objective 8

a. Anchor
b. Jam
c. Flange lock or self-locking
d. Castle
e. Distorted thread
f. Thread lock bolt
g. Plastic insert lock
h. Prevailing torque lock
i. Lock
j. Slotted

Answers to Written Test

Objective 9

a. Lock ears
b. Countersunk washer
c. Lock washer
d. Lock wires or safety wires
e. External tooth locked washer
f. Flat metal locks
g. Wave washer or Spring washer
h. Cotter pin
i. Flat washer
j. Internal tooth locked washer
k. Spring washer or Belleville washer

Objective 10

a. Spring lock pin
b. General-purpose rivet
c. External hole snap ring
d. Countersunk rivet
e. Internal prong snap ring
f. Adhesive
g. Lock pin
h. Split rivet
i. Springs
j. Internal hole snap ring
k. Woodruff key
l. Hollow rivet or pop rivet
m. Square key
n. Clevis pin
o. Lock ring
p. Clips
q. External "E" snap ring
r. Clamps

Objective 11

b, c, f, h

Objective 12

a. Paste-type
b. "Seizing"
c. Temperature
d. Glass beads

Objective 13

a. Die stock
b. Dies
c. Adjustable handle tap wrench
d. Thread pitch gauge
e. Taps
f. T-handle tap wrench

Objective 14

a. B
b. C
c. A
d. C
e. A
f. B
g. A

Objective 15

a. 2
b. 3
c. 1

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 6, and Student Supplements 1 and 2.

☐ 4. **View** Different sizes of standard and metric fasteners and the various types of bolt and screw head designs.

☐ 5. **Practice** Measuring different bolts and threads.

☐ 6. **Do** Assignment Sheet 1, "Measure U.S. Customary Bolts and Threads," and Assignment Sheet 2, "Measure Metric Bolts and Threads."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheets. If the evaluations are satisfactory, continue to step 8. If either evaluation is not satisfactory, repeat steps 3, 5, 6, and 7.

☐ 8. **Do** Assignment Sheet 3, "Match Bolts With the Correct Size Wrenches."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, repeat steps 3, 8, and 9.

☐ 10. **Study** Information Sheet, Objectives 7 through 13.

☐ 11. **Observe** Demonstration of procedure to be used in completing Job Sheet 1.

Learning Activities Sheet

☐ 12. **Do** Job Sheet 1, "Extract a Broken Bolt, Stud, or Screw."

☐ 13. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 1, and repeat steps 12 and 13.

☐ 14. **Study** Information Sheet, Objectives 14 and 15.

☐ 15. **Observe** Demonstration of procedure to be used in completing Job Sheet 2.

☐ 16. **Do** Job Sheet 2, "Restore External Threads."

☐ 17. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 2, and repeat steps 16 and 17.

☐ 18. **Observe** Demonstration of procedure to be used in completing Job Sheet 3.

☐ 19. **Do** Job Sheet 3, "Cut and Restore Internal Threads."

☐ 20. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 21. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 3, and repeat steps 19 and 20.

☐ 21. **Observe** Demonstration of procedure to be used in completing Job Sheet 4.

☐ 22. **Do** Job Sheet 4, "Install a Thread Insert."

☐ 23. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 24. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 4, and repeat steps 22 and 23.

☐ 24. **Check** With instructor for any additional assignments to be completed.

☐ 25. **Do** Additional assignments listed below.

____

____

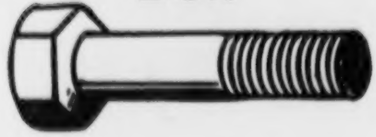
____

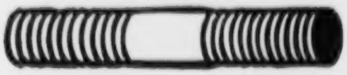
☐ 26. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

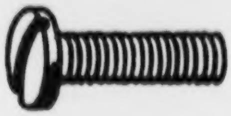
☐ 27. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

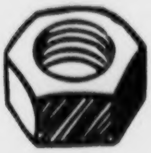
***Permission to duplicate this form is granted.**

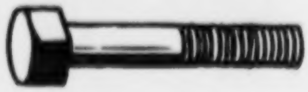
Typical Threaded Fasteners

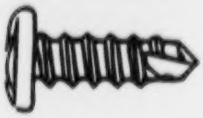

Bolt

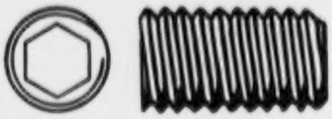

Stud


Machine screw

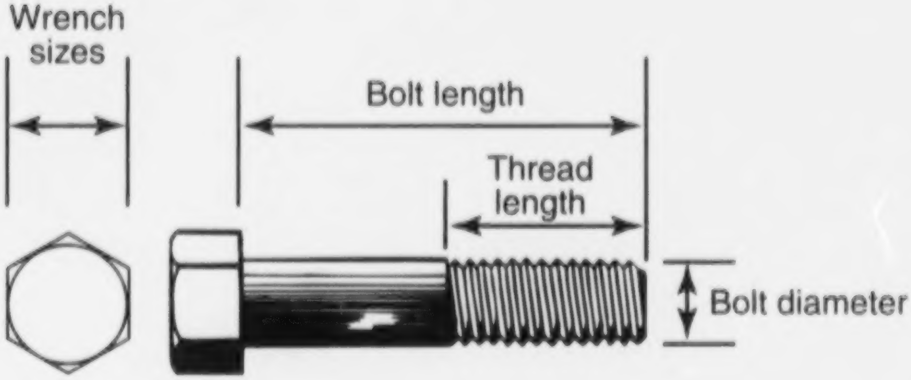

Nut

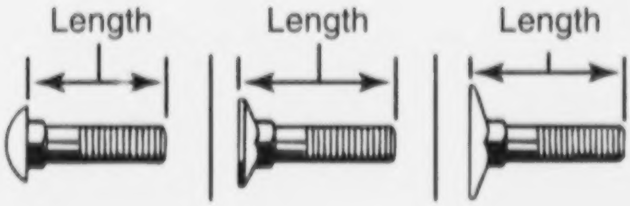

Cap screw


Self-tapping screw

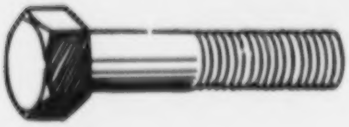

Set screw

Threaded Fastener Dimensions

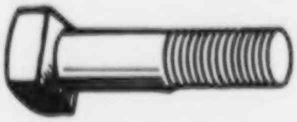

Wrench sizes
Bolt length
Thread length
Bolt diameter


Length
Length
Length

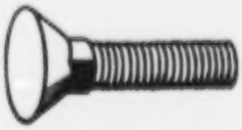
Typical Bolt Head Designs



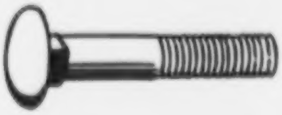
Hex head



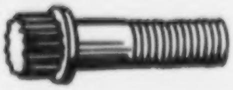
Square head
cap screw



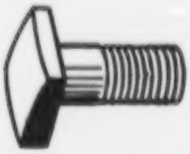
Plow head



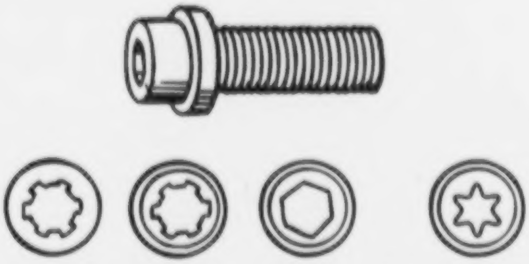
Carriage bolt



Twelve-point head

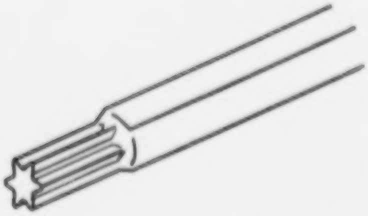


Askew head



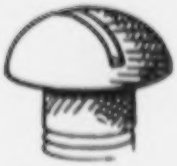
Torx® Spline Allen Security Torx®

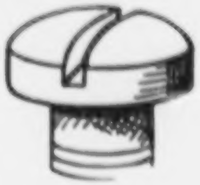
Socket head

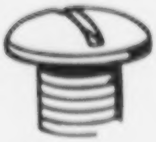


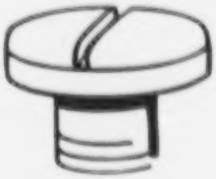
External Torx® head

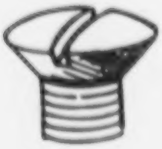
Typical Machine Screw Head Design

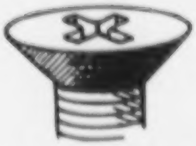

Round

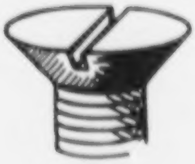

Fillister

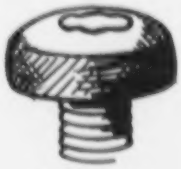

Truss

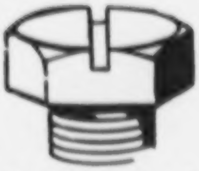

Pan

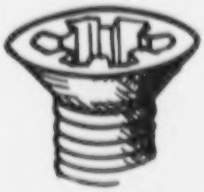

Oval


Cross Recessed or Phillips®

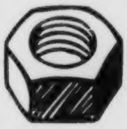

Flat

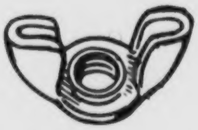

Clutch

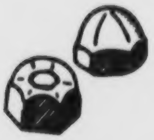

Hex slotted

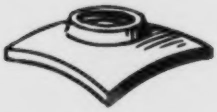

Torx®

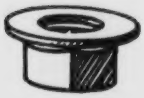
Typical Nuts

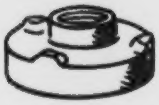

Hex nut

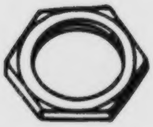

Wing nut

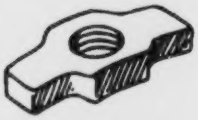

Acorn nuts

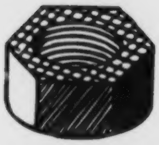

Spring nut

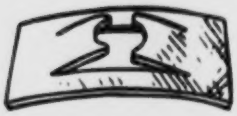

Flanged nut

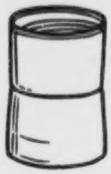

Weld nut

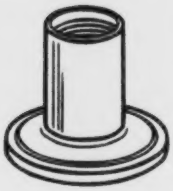

Panel nut

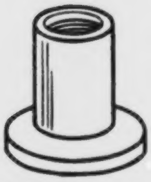

Specialty nut


Serrated nut

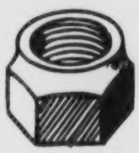

Wing nut

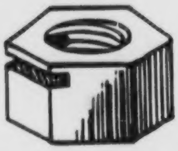

Nutsert®

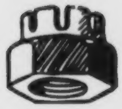

T-nut

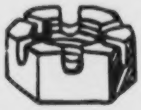

Well nut

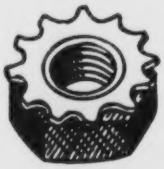
Typical Nuts and Bolts with Locking or Self-Locking Features

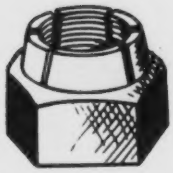

Lock

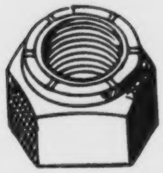

Distorted thread

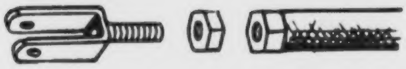

Castle

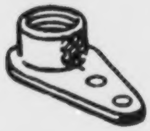

Slotted

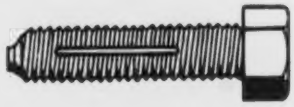

Flange lock or self-locking


Prevailing torque lock

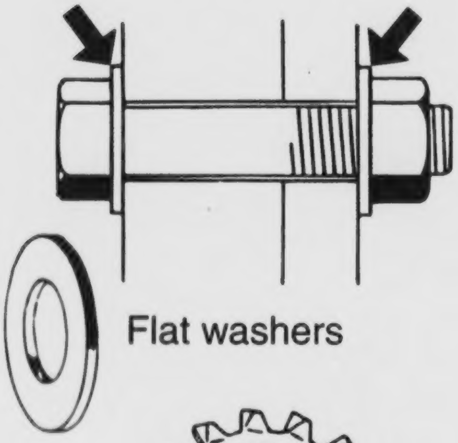

Plastic insert lock


Jam

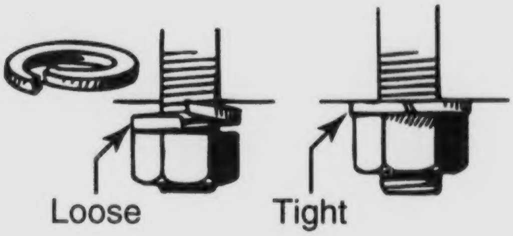

Anchor


Thread lock bolt (nylon insert)

Devices Used for Securing Threaded Fasteners

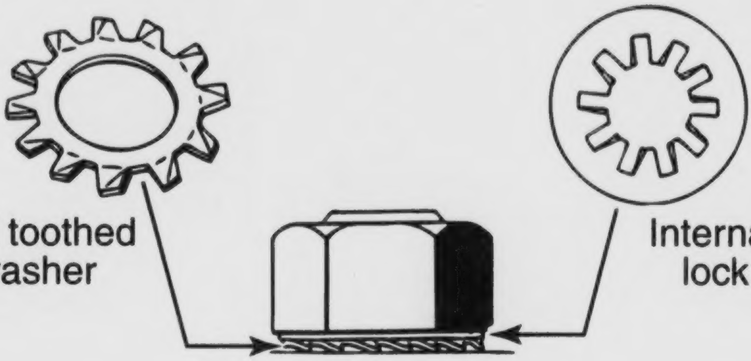


Flat washers



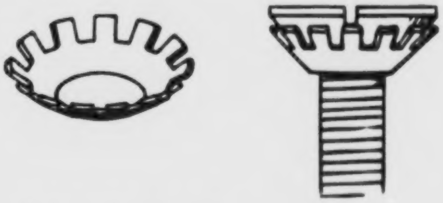
(washer grips)

Lock washers

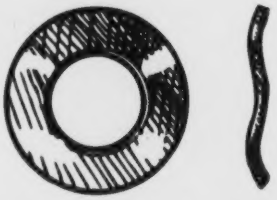


External toothed lock washer

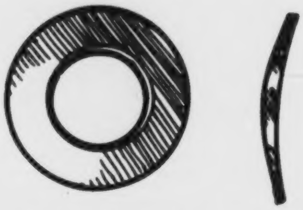
Internal toothed lock washer



Countersunk washer



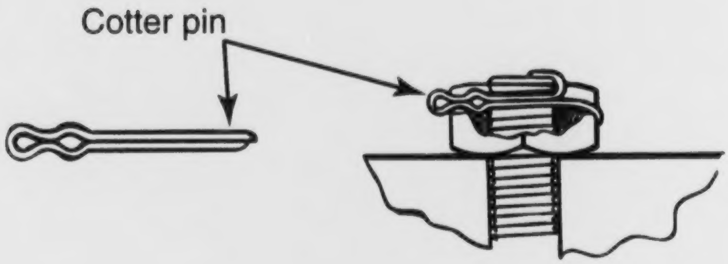
Wave (spring) washer

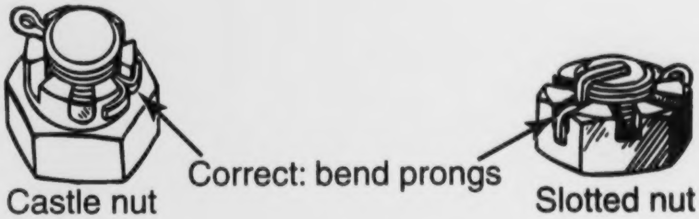


Spring (Belleville) washer

Devices Used for Securing Threaded Fasteners

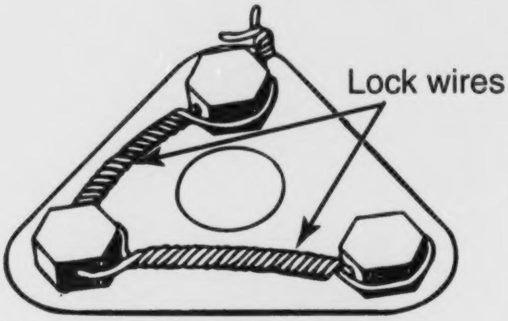
(Continued)



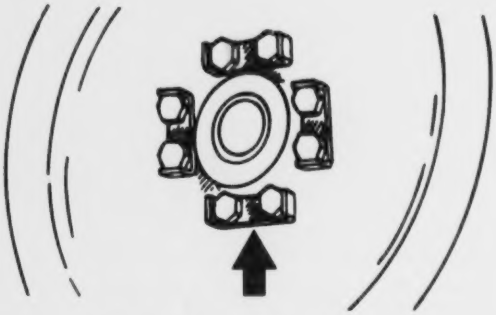

Correct: bend prongs

Castle nut

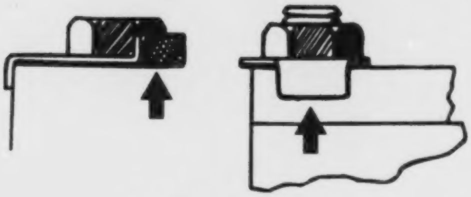
Slotted nut



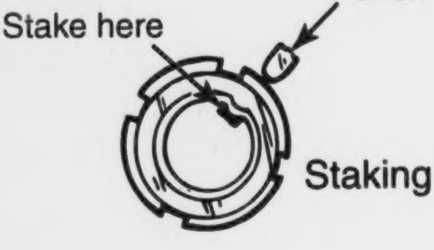
Lock (safety) wires



Flat metal locks

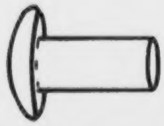


Lock ears

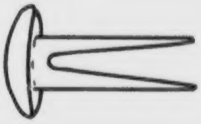

Punch
Stake here

Staking nut

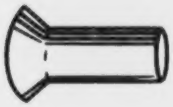
Typical Nonthreaded Fasteners



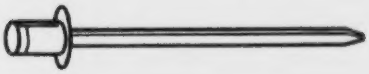
General-purpose rivet



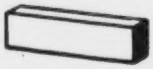
Split rivet



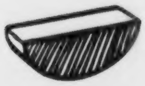
Countersunk rivet



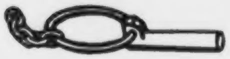
Hollow (pop) rivet



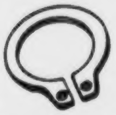
Square key



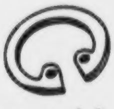
Woodruff key



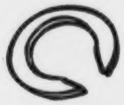
Lock pin



External hole snap ring

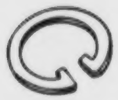


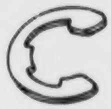
Internal hole snap ring

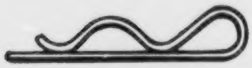


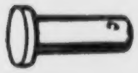
Lock ring

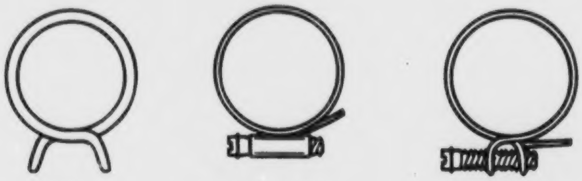
Typical Nonthreaded Fasteners
(Continued)


Internal prong snap ring

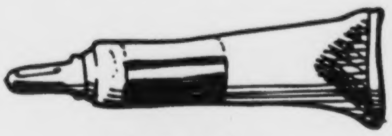

External "E" snap ring

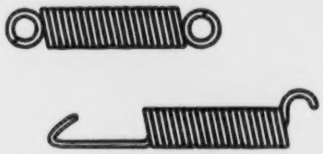

Spring lock pin

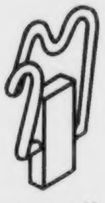

Clevis pin

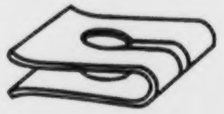

Wire Worm-drive Banded

Clamps

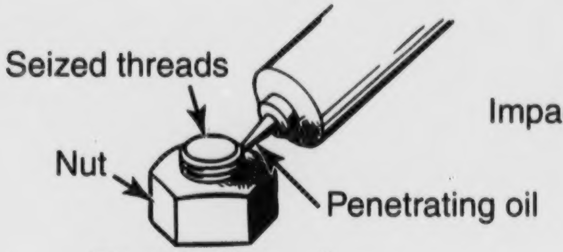

Adhesive


Spring

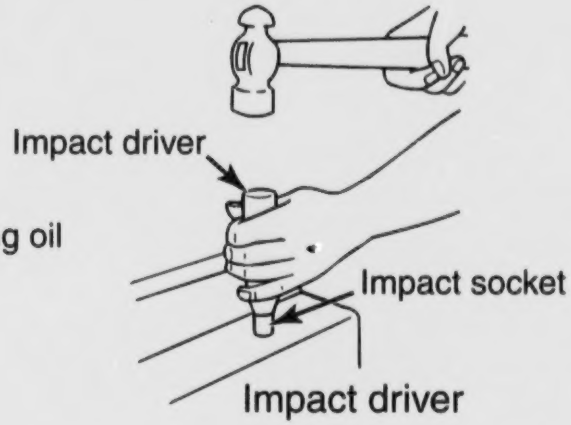

Snap clip


Retaining clip

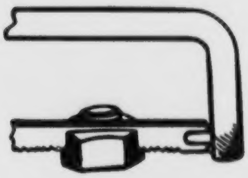
Tools Used to Remove Seized Threaded Fasteners


Seized threads
Nut
Penetrating oil

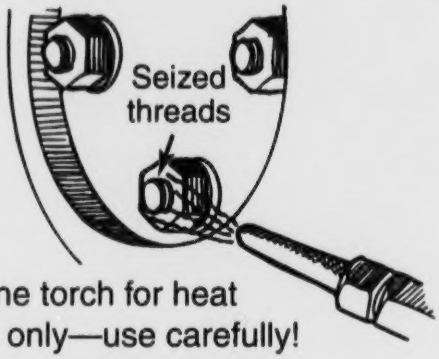
Penetrating oil


Impact driver
Impact socket

Impact driver

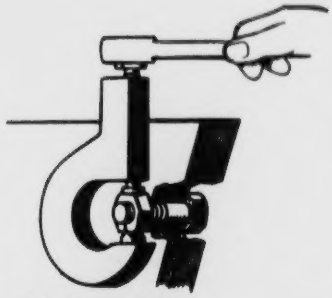


Hacksaw

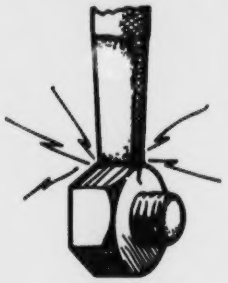

Seized threads

Acetylene torch for heat
Apply to nut only—use carefully!

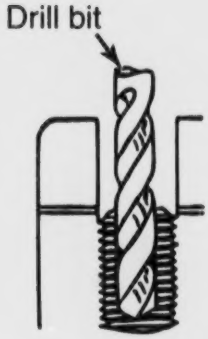
Acetylene torch



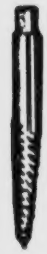
Nut-splitter



Chisel

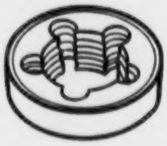


Drill

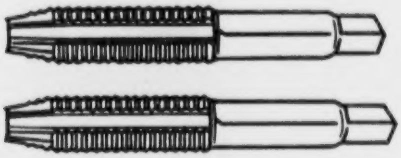


Tapered screw (spiral)
Extractor

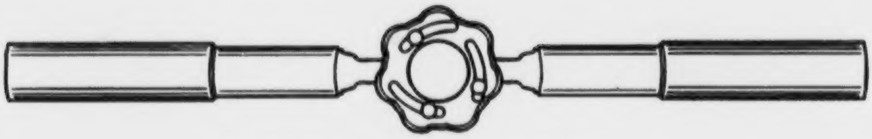
Parts of a Tap and Die Set



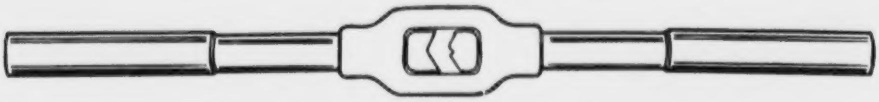
Solid die



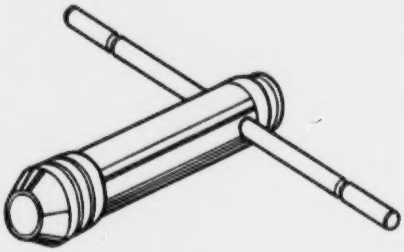
Taps



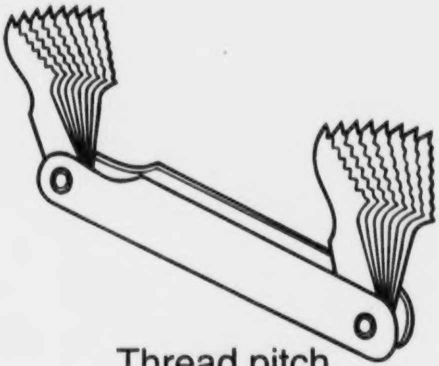
Die stock threading tool



Adjustable handle tap wrench

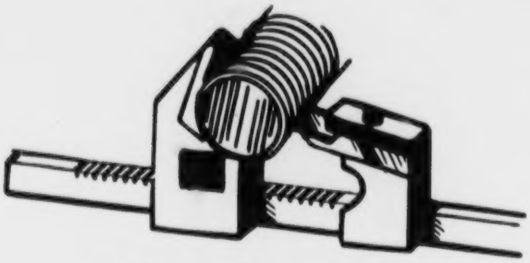


T-handle tap wrench

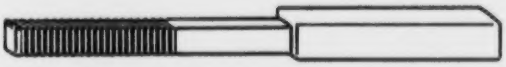


Thread pitch gauge

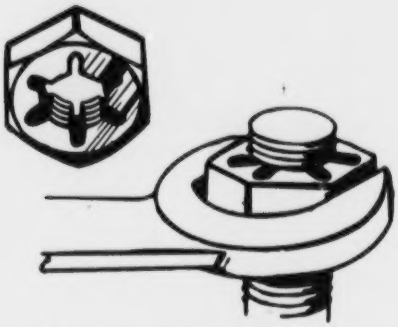
Tools Used to Restore or Replace Threads on Threaded Fasteners



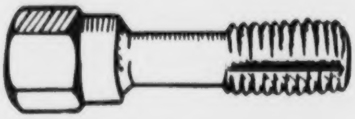
Rethreading tool
(external chaser)



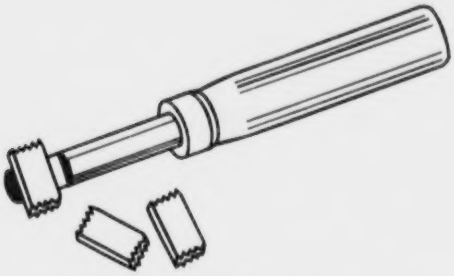
Thread file



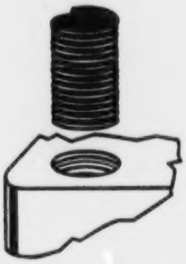
Rethreading die



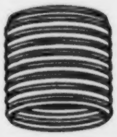
Rethreading hand tap



Internal thread chaser

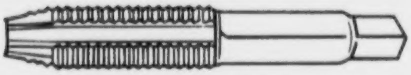


Locking threaded inserts

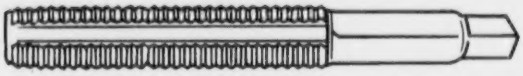


Coiled threaded insert

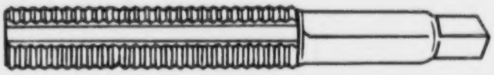
Types of Taps



Taper tap



Plug tap



Bottoming tap

TM 14

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 2B-3
Written Test 2B-9
Answers to Written Test 2B-15
Learning Activities Sheet 2B-17
Transparency Masters
  1—Sizes and Pressures of Steel Pipe 2B-19
  2.—Sizing of Metal Tubing 2B-21
  3—SAE Nylon Tubing 2B-23
  4—Tubing Fittings 2B-25
  5—Types of Hose Ends 2B-27
  6—Common Configurations of Hose Ends 2B-29
  7—Common Valves 2B-31
  8—Accessories 2B-33

Student Components

Student Page

Objective Sheet 2B-3
Information Sheet 2B-5
Assignment Sheets
  1—Describe Characteristics of Pipe, Tubing, and Hose 2B-23
  2—Identify Fittings and Threads 2B-29
Job Sheets
  1—Replace a Skive Hose End 2B-31
  2—Replace a No Skive Hose End 2B-33

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Discuss and show the types of equipment and systems that use lines, fittings, and couplings covered in this unit.
- Discuss the hazards of incorrectly or improperly installed lines, fittings, and couplings. Relate personal experiences of accidents you have seen or been involved in that resulted in personal injuries or property/equipment damage because of improperly installed lines, fittings, or couplings.
- Explain appropriate safety procedures to follow when working on lines, fittings, and couplings, especially on high pressure lines.
- Show examples of the different types of lines used on diesel equipment. Include various pipes, metal and plastic tubing, and hoses. Discuss their differences and how they will be used.
- Cut a piece of tubing to show the difference between inside diameter and outside diameter.
- Cut two pieces of hose—one high pressure and one low pressure—to show the various layers that make up the hose and the difference between the reinforcements used for high and low pressure lines.
- Make a display of the various fittings and couplings used on pipe, tubing, and hose. Also include replacement catalogs so students can see how many parts are available and how easy it could be to use the wrong replacements. Many look the same on the outside but are very different in their recommended uses.
- Show examples of common valves. Cutaways, if available, would be especially useful to show how they operate.
- Discuss and demonstrate the correct use and installation of pipe, tubing, and hose.
- Provide examples of pipe, tubing, and hose for students to identify in Assignment Sheet 1 and examples of fittings for students to identify in Assignment Sheet 2.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

Suggested Activities

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper.* Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair*, 3rd edition. Upper Saddle River, NJ: Prentice Hall, 1994.
- Decker, Robert L. Revised by Klane Kirby. *Hydraulics*, 2nd edition. Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1986.
- *Fundamentals of Service: Hoses, Tubing, and Connectors.* Moline, IL: Deere and Company, 1993.
- *Fundamentals of Service: Hydraulics.* Moline, IL: Deere and Company, 1992.
- Lee, R. R. *Pocket Guide to Flanges, Fittings, and Piping Data.* Gulf Publishing Company, 1992.
- *Parker Fluid Connectors Catalog.* Wickliffe, OH: Fleet Products.
- Schultz, Erich J. *Diesel Mechanics*, 4th ed. New York: Glencoe/McGraw-Hill, 1999.

Suggested Supplemental Resources

Print Media

- *Hydraulic Hose and Fittings Service Guide* (W2-4DMS)—Covers hydraulic components, tubing, pipe fittings, hose ends, coll-o-crimp, and hose failure analysis. Available from:

  Dana Corporation
  Publication Services
  P.O. Box 453
  Toledo, OH 43692-0453
  419-535-4285

- *NAPA Hydraulic Hose Field Guide.* Covers history and development of hydraulics, hose construction, coupling selection, and hose assembly replacement tips. Available from:

  NAPA Belts/Hose
  Advertising/Customer Service Department
  P.O. Box 5887
  Denver, CO 80217

- *Gates College of Fleet Knowledge: Belts and Hoses*

- *Gates College of Fleet Knowledge: Hydraulics and Metal Goods*

  The above two publications are available from:

  The Gates Rubber Company
  Automotive Advertising Department
  P.O. Box 5887
  Denver, CO 80217
  303-744-1911

Electronic Media

- *Hydraulic Hose Press* (SEVN9124), 45-minute video that demonstrates how to cut hose, skive, remove and install fittings, and recondition used fittings. Available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

Unit 2-B Lines, Fittings, and Couplings

Written Test

Name ____________________

Date ____________________ Score __________

Objective 1

Match the terms with their definitions.

1. Burst pressure
2. Coupler
3. Department of Transportation (DOT)
4. Fitting
5. Hose
6. Hose end
7. Joint Industrial Council (JIC)
8. Line
9. American or national standard tapered thread (NPT)
10. National taper pipe thread or dry seal American (NPTF)
11. Pipe
12. Pounds per square inch (PSI)
13. Skive
14. Tube
15. Working pressure

_____ a. Semi-rigid line that is customarily bent into a desired shape

_____ b. Flexible line that can readily bend for ease of installation or to accommodate movement of components

_____ c. Non-threaded fitting used to join lines that are frequently disconnected

_____ d. Maximum amount of pressure that a component is expected to build when functioning

_____ e. Device for connecting lines to components or to other lines

_____ f. Any tube, flexible or rigid, through which fluid or gas is conducted from one component to another

_____ g. Amount of pressure that a component is designed to withstand before breaking

_____ h. Standard thread that creates a seal without pipe sealing compound

_____ i. Fitting attached onto a hose

_____ j. To remove the outer covering on a hose

_____ k. Federal agency that sets transportation standards affecting vehicle design and manufacturing

_____ l. Rigid line that is not intended to be bent or shaped

Written Test

Objective 2

Name three applications that use lines,fittings, or couplings.

a. ________________________________

b. ________________________________

c. ________________________________

Objective 3

Discuss four hazards of incorrect or improperly installed lines, fittings, and couplings.

a. ________________________________

b. ________________________________

c. ________________________________

d. ________________________________

Objective 4

Distinguish between correct and incorrect rules for safe use and installation of lines, fittings, and couplings by placing:

- I = next to incorrect rules
- C = next to correct rules

_____ a. Always use lines and fittings that are compatible with the fluids they will convey.

_____ b. Always use a bend radius smaller than a line's specified minimum bend radius.

_____ c. Always uses lines and fittings that have maximum working pressures less than the maximum system pressure.

_____ d. Always use lines and fittings that can withstand any elements to which they are exposed.

_____ e. Always use conductive lines in installations exposed to high voltage electricity.

_____ f. Always use lines and fittings capable of withstanding the system's temperature extremes.

_____ g. Always use lines capable of withstanding the system's vacuum in suction applications.

_____ h. Always select lines and fittings by burst pressure.

_____ i. Never inspect lines, fittings, and couplings before installation.

_____ j. Regularly inspect, test, and replace lines, fittings, and couplings at specified intervals.

Objective 5

Select true statements concerning characteristics of pipe by placing a "T" next to true statements and an "F" next to false statements.

_____ a. Galvanized pipe is acceptable material in heavy equipment applications.

_____ b. Pipe size is typically stated by nominal inside diameter.

_____ c. The wall thickness of any given size of pipe is stated as a schedule number; the lower the schedule number, the thicker the wall.

_____ d. Each size of pipe will have the same working pressure and burst pressure.

_____ e. Use seamless, cold-drawn mild steel for hydraulic applications.

Objective 6

Complete the following statements concerning characteristics of metal tubing by circling the correct answers.

a. Two types of steel tubing are commonly available: Seamless and (electric welded, arc welded).

b. Aluminum flares and bends (better, worse) than copper.

c. Copper is generally used in systems with (low, high) pressure and (little, much) vibration.

d. Size is indicated by (inside, outside) diameter and wall thickness.

Objective 7

Select true statements concerning characteristics of nylon and plastic tubing by placing a "T" next to true statements and an "F" next to false statements.

_____ a. Plastic tubing is characterized by high pressure.

_____ b. Nylon tubing is characterized by low pressure.

_____ c. Size is stated in terms of maximum burst pressure.

Objective 8

Complete the following statements concerning characteristics of flexible hose by filling in the blanks with the correct answers.

a. Flexible hose is made of the following layers:

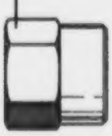
- _______________
- Reinforcement layers
- _______________

b. Low pressure applications use _______________.

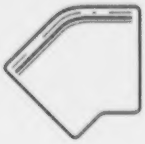
c. Size is stated in terms of the following factors:

- Inside diameter
- ____________________
- ____________________

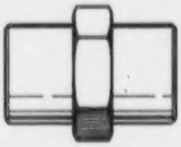
Objective 9 Identify the following types of fittings commonly used with pipe. Write your answers in the blanks provided.



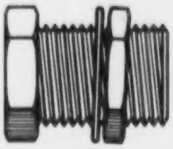
a. ____________________



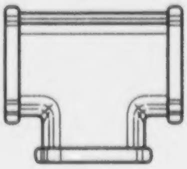
b. ____________________



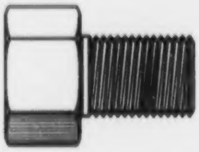
c. ____________________



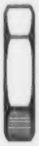
d. ____________________



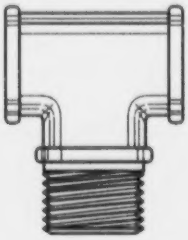
e. ____________________



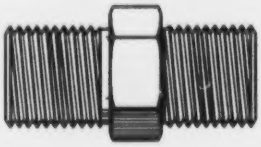
f. ____________________



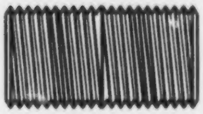
g. ____________________



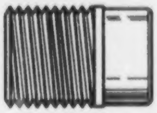
h. ____________________



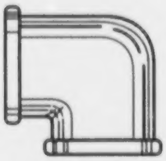
i. ____________________



j. ____________________



k. ____________________



l. ____________________

Objective 10

Distinguish between types of fittings commonly used with tubing by placing:

- A = next to characteristics of **flared** fittings
- B = next to characteristics of **flareless** fittings

_____ a. The most common angle is 37°

_____ b. Are reusable

_____ c. Standard fitting of this type consists of a body, a sleeve, and a nut

_____ d. May be swage-type, bite-type, or brazed

Objective 11

Distinguish among types of hose ends by placing:

- P = next to permanent hose ends
- N = next to no skive hose ends
- S = next to skive hose ends
- C = next to clamps on hose ends

_____ a. The hose cover is removed before installation of the hose end.

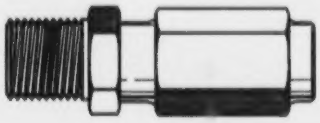
_____ b. The fitting is crimped or swaged onto the hose.

_____ c. The hose cover is not removed.

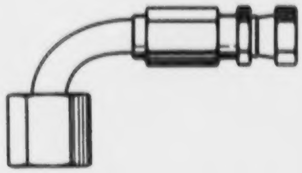
_____ d. This is used only in low pressure systems.

Objective 12

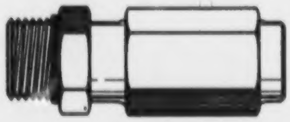
Identify the following common configurations of hose ends. Write your answers in the blanks provided.



a. ______________________



b. ______________________

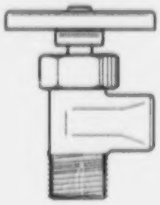


c. ______________________

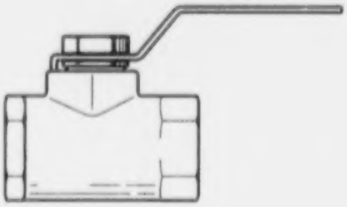
Written Test

Objective 13

Identify the following common valves. Write your answers in the blanks provided.



a. ______________________



b. ______________________

Objective 14

Match the types of accessories with their special applications.

1. Coil
2. Fire sleeve
3. Hose support clamp
4. Spring guard

_____ a. Protects exposed hose

____ b. Connects lines between units such as tractor-trailer combinations

____ c. Secures and protects long lines

Objective 15

Complete statements concerning the installation of pipe or tubing by filling in the blanks with the correct answers.

a. Avoid straight-line hookups because ______________________.

b. Use the ______________________ bends possible.

c. Support ______________________ of tubing.

d. Avoid interference with ______________________.

Objective 16

Distinguish between correct and incorrect installation of hose by placing:

- I = next to incorrect installation of hose
- C = next to correct installation of hose

_____ a. Twist the hose.

____ b. Make sharp bends.

____ c. Avoid rubbing.

____ d. Put the hose in contact with heat.

____ e. Avoid loops.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 14
b. 5
c. 2
d. 15
e. 4
f. 8
g. 1
h. 10
i. 6
j. 13
k. 3
l. 11

Objective 2

Any three of the following:

a.. Air brake systems
b. Air conditioning systems
c. Cooling and heating systems
d. Fuel systems
e. Hydraulic systems
f. Lubrication systems

Objective 3

Discussion should include any four of the following (in student's own words):

a. Fittings thrown off at high speed
b. High velocity fluid discharge
c. Explosion or burning of the conveyed fluid
d. Electrocution from high voltage electric power lines or other sources of electricity
e. Contact with suddenly moving or falling objects that are to be held in position or moved by the conveyed fluid
f. Dangerously whipping hose
g. Contact wit conveyed fluids that may be hot, cold, toxic, or otherwise harmful
h. Sparking or explosion caused by static electricity buildup
i. Sparking or explosion while spraying paint or flammable liquids

Objective 4

a. C
b. I
c. I
d. C
e. I
f. C
g. C
h. I
i. I
j. C

Objective 5

a. F
b. T
c. F
d. F
e. T

Objective 6

a. Electric welded
b. Better
c. Low, little
d. Outside

Objective 7

a. F
b. F
c. F

Answers to Written Test

Objective 8	a.	Inner tube, outer cover
	b.	Fiber braid
	c.	Working pressure, construction
Objective 9	a.	Cap
	b.	45° female elbow
	c.	Coupling
	d.	Anchor connector
	e.	Union tee
	f.	Adapter
	g.	Lock nut
	h.	Male branch tee
	i.	Hex nipple reducer
	j.	Close nipple
	k.	Square head plug
	l.	90° union elbow
Objective 10	a.	A
	b.	B
	c.	A
	d.	B
Objective 11	a.	S
	b.	P
	c.	N
	d.	C
Objective 12	a.	Male pipe hose end
	b.	37° swivel, 90° elbow hose end
	c.	Straight thread O-ring hose end
Objective 13	a.	Stem valve
	b.	Ball valve
Objective 14	a.	4
	b.	1
	c.	3
Objective 15	a.	They do not allow for adequate expansion and contraction
	b.	Fewest and/or simplest
	c.	Long runs
	d.	Operator controls
Objective 16	a.	I
	b.	I
	c.	C
	d.	I
	e.	C

Prerequisites:
1-B

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 8.

☐ 4. **View** Different sizes of pipe, tubing, and hoses and study their characteristics.

☐ 5. **Do** Assignment Sheet 1, "Describe Characteristics of Pipe, Tubing, and Hose."

☐ 6. **Stop** Ask instructor to evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat steps 3, 5, and 6.

☐ 7. **Study** Information Sheet, Objectives 9 through 13.

☐ 8. **Practice** Identifying actual fittings and threads and compare the good and bad threads.

☐ 9. **Do** Assignment Sheet 2. "Identify Fittings and Threads."

☐ 10. **Stop** Ask instructor to evaluate the completed assignment sheet. If the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat steps 7 through 10.

☐ 11. **Study** Information Sheet, Objectives 14 through 16.

☐ 12. **Observe** Demonstration of procedures to be used in completing Job Sheets 1 and 2.

Learning Activities Sheet

☐ 13. **Do** Job Sheet 1, "Replace a Skive Hose End," and Job Sheet 2, "Replace a No Skive Hose End."

☐ 14. **Stop** Have instructor evaluate your performance on each procedure, and if the evaluations are satisfactory, continue to step 15. If either evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedures outlined in Job Sheets 1 and/or 2, and repeat steps 13 and 14.

☐ 15. **Check** With instructor for any additional assignments to be completed.

☐ 16. **Do** Additional assignments listed below.

☐ 17. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 18. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Sizes and Pressures of Steel Pipe

Nominal Size	Pipe O.D.	Inside Diameter Schedule 40	Working Pressure (Burst Pressure) Schedule 40
1/8	.405	.269	3500 (20,200)
1/4	.540	.364	2100 (19,500)
3/8	.675	.493	1700 (16,200)
1/2	.840	.622	2300 (15,600)
3/4	1.050	.824	2000 (12,900)
1	1.315	1.049	2100 (12,100)
1 1/4	1.660	1.380	1800 (10,100)
1 1/2	1.900	1.610	1700 (9,100)
2	2.375	2.067	1500 (7,800)

Sizing of Metal Tubing

Tubing O.D.	Wall Thickness	Tubing I.D.
1/8	0.028	0.069
	.032	.061
	.035	.055
3/16	0.032	0.1235
	.035	.1175

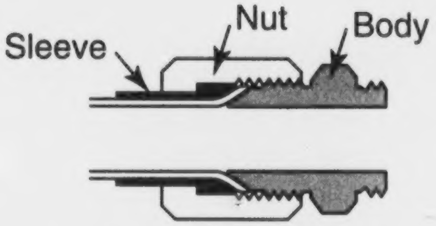
SAE Nylon Tubing

SAE Number	Inner Tube	Reinforcement	Cover
SAE 100R1	Synthetic Rubber	1 High Tensile Steel	Synthetic Rubber
SAE 100R2	Synthetic Rubber	2 Wire Braids 2 Spiral Plies and 1 Wire Braid	Synthetic Rubber
SAE 100R3	Synthetic Rubber	2 Textile Braids	Synthetic
SAE 100R4	Synthetic Rubber	Braided Textile Fibers/Spiral Body Wire	Synthetic
SAE 100R5	Synthetic Rubber	1 Textile Braid 1 High Tensile Steel Wire Braid	Cotton Braid
SAE 100R6	Synthetic Rubber	1 Textile Braid	Synthetic Rubber
SAE 100R7	Thermoplastic	Synthetic Fiber	Thermoplastic
SAE 100R8	Thermoplastic	Synthetic Fiber	Thermoplastic
SAE 100R9	Synthetic Rubber	4 Spiral Plies Wrapped in Alternating Directions	Synthetic Rubber
SAE 100R10	Synthetic Rubber	4 Spiral Plies of Heavy Wire Wrapped in Alternating Directions	
SAE 100R11	Synthetic Rubber	6 Spiral Plies of Heavy Wire Wrapped in Alternating Directions	Synthetic Rubber

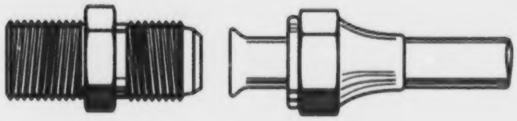
TM 3

Tubing Fittings

Flared

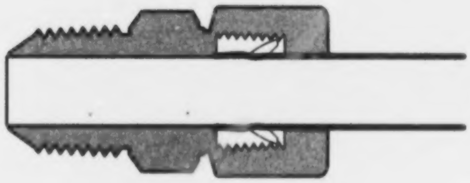

Sleeve
Nut
Body

Standard three-piece flared fitting

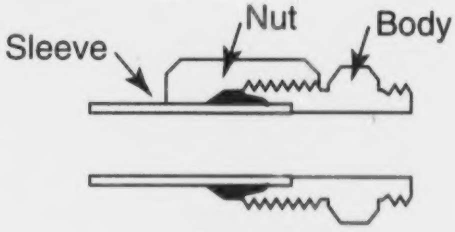


Two-piece flared fitting

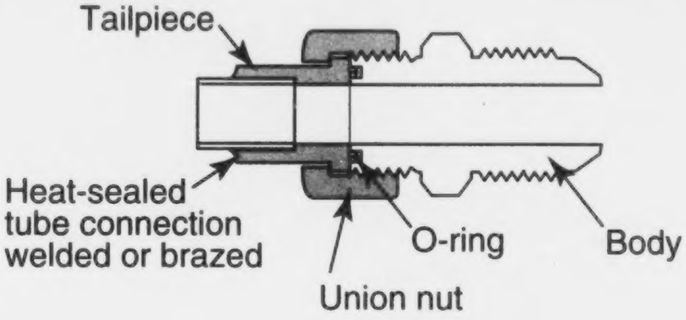
Flareless



Compression or swage-type fitting

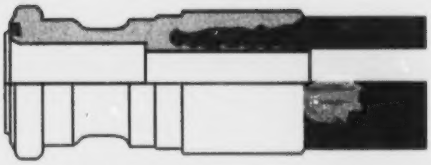

Sleeve
Nut
Body

Ferrule or bite-type fitting

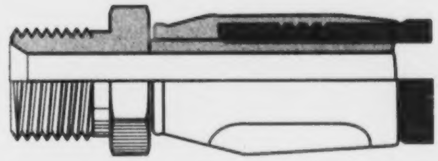

Tailpiece
Heat-sealed tube connection welded or brazed
Union nut
O-ring
Body

O-ring or braze-on fitting

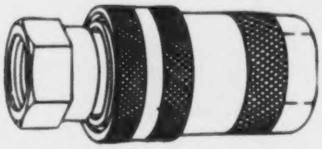
Types of Hose Ends



Permanent hose end

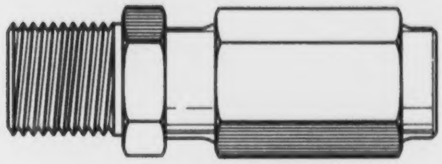


Reusable hose end

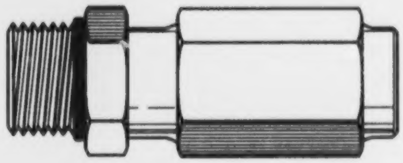


Quick disconnect
coupler hose end

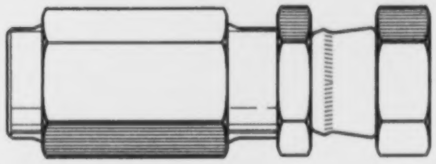
Common Configurations of Hose Ends



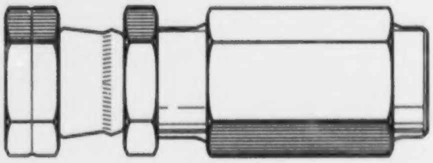
Male pipe hose end



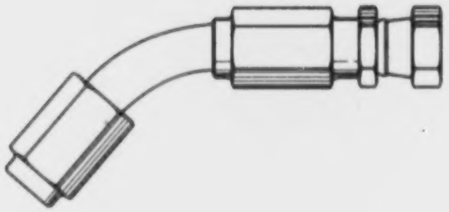
Straight thread
O-ring hose end



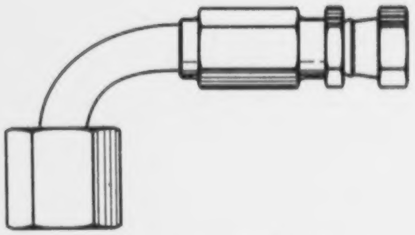
37° swivel hose end



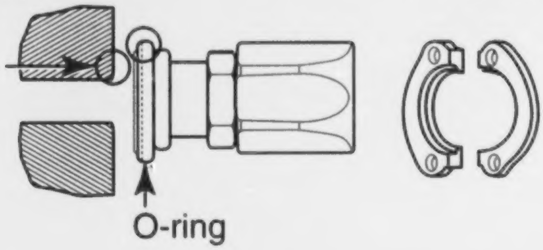
45° swivel hose end



37° swivel, 45° elbow
hose end

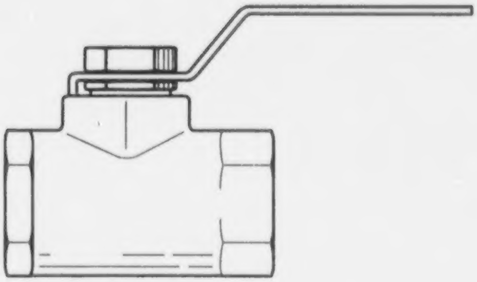


37° swivel, 90° elbow
hose end

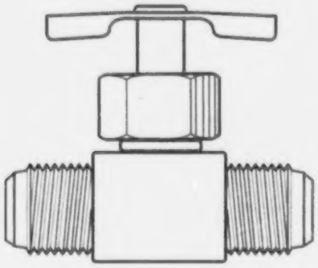


Flange o-ring seal hose end

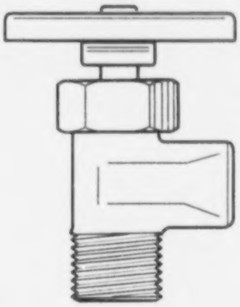
Common Valves



Ball valve

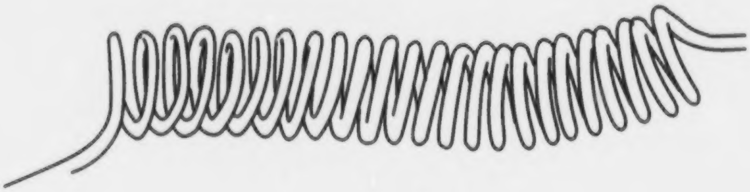


Needle valve

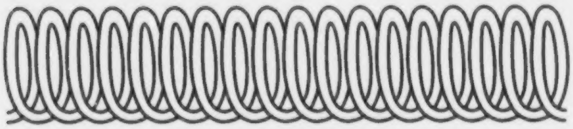


Stem valve

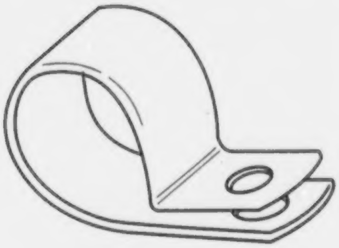
Accessories



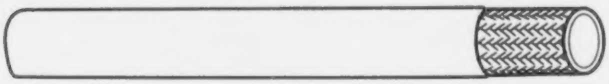
Coil



Spring guard



Hose support clamp



Firesleeve

Unit 3-B Seals and Bearings

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 3B–3

Written Test 3B–11

Answers to Written Test 3B–21

Learning Activities Sheet 3B–25

Transparency Masters

1—Common Seals 3B–29
2—Parts of a Lip Seal 3B–31
3—Types of Packings 3B–33
4—Examples of Gaskets 3B–35
5—Major Types of Bearings 3B–37
6—Major Types of Bearings (Continued) 3B–39
7—Parts of an Antifriction Bearing 3B–41

Student Components

Student Page

Objective Sheet 3B–3

Information Sheet 3B–5

Job Sheets

1—Install a Radial Lip Seal 3B–23
2—Remove and Install an Engine Oil Seal and Wear Sleeve 3B–25
3—Install a Packing 3B–29
4—Replace a Formed Gasket 3B–31
5—Replace a Formed-In-Place Gasket 3B–33
6—Remove and Install a Camshaft Friction Bearing 3B–35
7—Remove and Install an Antifriction Bearing 3B–39
8—Clean and Pack an Antifriction Bearing 3B–41

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Use mock-ups to demonstrate the functions of seals and gaskets.
- Display various types of seals, packings, gaskets, and sealants. Have students explain the differences between these products. Include different designs and different materials.
- Discuss where on the diesel-powered vehicle the various seals would be used. Show examples of wheel seals, engine seals, pump seals, head gaskets, etc. Have students walk around a vehicle while you point out the various types of seals.
- Show examples of different types of bearings, making sure students understand the difference between friction bearings and antifriction bearings.
- Discuss where on the diesel-powered vehicle the two basic types of bearings would be used. Show examples of wheel bearings, engine bearings, etc. Have students walk around a vehicle while you point out the various types of bearings.
- Discuss general guidelines for replacing seals and bearings. Emphasize the importance of following manufacturers' recommendations for replacements.
- Show special tools that may be used to remove and install seals and bearings. Demonstrate their proper use and application.
- Discuss "preloading" required on some bearings and the proper procedure to do this.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper.* Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair,* 3rd ed. Upper Saddle River, NJ: Prentice Hall, 1994.

Suggested Activities

- *Introduction to Automotive Service*. Stillwater, OK: Curriculum and Instructional Materials Center/Oklahoma Department of Vocational and Technical Education, 1989.

- *Fundamentals of Service: Bearings and Seals*. Moline, IL: Deere and Company, 1992.

- *Fundamentals of Service: Hydraulics*. Moline, IL: Deere and Company, 1992.

- Schultz, Erich J. *Diesel Mechanics*, 4th ed. New York: Glencoe/McGraw-Hill, 1999.

Suggested Supplemental Resources

Print Media

- *Adhesives, Sealers, and Related Items*—General Motors 10-page booklet covering available products, purposes, brand names, and part numbers. Available from:

  Automotive Service Association
  P.O. Box 929
  Bedford, TX 76095-0929
  800-272-7467 or 817-283-6205

- *Failure Analysis—Bearings* (985573)

- *Sealing Failures—Causes and Cures* (3387169)

- *Capscrew Torque and Preload* (3387304)

  The above are available as books or slide sets from your local Cummins Engine Company dealer/distributor or call:

  Cummins Engine Company Customer Relations
  800-345-5654 or 502-453-8549 or for more information call 800-DIESELS

- *Gasket Installation Manual* and assortment of technical bulletins compiled into an educational packet. Available from:

  Fel-Pro
  7450 N. McCormick Blvd.
  Skokie, IL 60076-8205
  800-FELPRO1 or 847-674-7700

- CR instructional manuals and self-study guides

  — *How to Install Seals* (#457809)—Covers installation procedures for automotive front and rear wheel seals and bearings

- *Shaft Seals (Heavy-Duty Fleet Edition)* (#457935)—Covers design, application, selection, installation, and troubleshooting for shaft seals. Also includes CR Scotseals and Speedi-Sleeves.

- *Roller and Ball Bearings* (#457640)—Includes design and function of single and dual brake systems.

The above are available from:

CR Services
735 Tollgate Road
Elgin, IL 60123
800-882-0008 or 847-742-7840

- *An Introduction to Bearings* (SEBV0507), 74-page book that describes the effects of heat, cold, friction, and wear on bearings. Also shows typical applications and use of service tools. (1989)
- *An Introduction to Seals and Gaskets* (SEBV0511), 94-page book. (1989)
- *Engine Bearing Failure Analysis* (SEBV0544), 20-page book. (1988)
- *Anti-friction Bearing Failure Analysis* (SEBV0562), 24-page book. (1990)

The above are available from your local CAT dealer or write the following for more information:

Caterpillar Service Training
600 W. Washington St., Bldg. JJ
East Peoria, IL 61630

- *Engine Bearing Service Manual* (1988), *National Oil Seals Specification Manual*, various brochures, and wall charts are available from:

Federal-Mogul Corporation
Marketing Communications Department
P.O. Box 1966
Detroit, MI 48235
810-354-7700

Suggested Activities

- *Hard-to-Find Seals and Gaskets Catalog*. Available from:

  EPM, Inc.
  240 Oak Leaf Drive
  Suite 1106
  Stockbridge, GA 30261
  800-659-5050
  http://www.epm.com

Electronic Media

- CR films/videos (VHS or beta)
  - *CR Bearings* (#458296) 10 minute-video—Discusses function and design of rolling element bearings, correct installation, and failure analysis.
  - *Shaft Surface Finish* (#458315) 8-minute video—Addresses key issues of shaft finishing.
  - *Automotive Seals and Bearings* (#458313)—Covers removal and installation of automotive wheel seals and bearings.

  The above are available from:

  CR Services
  735 Tollgate Road
  Elgin, IL 60123
  800-882-0008 or 847-742-7840

- *Sealing Technology—Hard Gaskets* (STE-6), 10-minute video
- *Sealing Technology—Soft Gaskets* (STE-7), 10-minute video
- *Understanding Oil Seals* (STC-4), 11-minute video
- *Gasket Technology* (VH1-65PT), 20-minute video

  The above are available from:

  Dana Corporation
  Publication Services
  P.O. Box 453
  Toledo, OH 43692-0453
  419-535-4285

- *FOS Bearing and Seals* set of 118 slides. Available from:

  Deere & Company
  Distribution Service Center
  P.O. Box 186
  Moline, IL 61266-1086

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions.

1. Arbor press
2. Babbit
3. Back-up ring
4. Bushing
5. Compress
6. Counterbore
7. Elastomeric
8. Friction
9. Gasket
10. Journal
11. O-ring
12. Press fit
13. Races
14. Seal
15. Sealant
16. Spindle
17. Splines

_____ a. Synthetic, elastic substance that resembles rubber

_____ b. Small shaft or axle

_____ c. Enlarged area around a seal or shaft to allow room for a seal or o-ring

_____ d. Tight fit between mating parts; must be "pressed" into place

_____ e. Material shaped to leakproof moving parts

_____ f. Thin material placed between surfaces of stationary parts to prevent leakage

_____ g. That part of a shaft, axle, or spindle that turns in a bearing

_____ h. Resistance to motion between two bodies in contact

_____ i. Type of gasket applied as a liquid, paste, or spray

_____ j. Soft metal (alloy of lead, tin, antimony, and other metals) commonly used to line bearings

_____ k. Ribbed or tooth-like portions of seals, bushings, pulleys, and other equipment

_____ l. Full, round, plain bearing

_____ m. Two hardened steel rings

_____ n. Simple seal with a round cross-section

Written Test

Objective 2

List two purposes of seals

a. ______________________________

b. ______________________________

Objective 3

Distinguish between the basic categories of seals and their uses by placing:

- D = next to dynamic seals
- S = next to static seals

_____ a. Used to make leakproof connection between **fixed** parts

____ b. Used to make leakproof connection between **moving** parts

____ c. Commonly used on shafts and rods, compression packings, and piston rings

____ d. Commonly used as gaskets, o-rings, packings, and sealers

Objective 4

Complete statements concerning common seals and their descriptions by circling the correct answers.

a. (Spring, Ring) seals are commonly used between a moving part and a stationary part.

b. (Radial lip, Ring) seals may be spring-loaded or springless.

c. (Mechanical, Electrical) seals are commonly used on pumps and hydraulic systems.

d. Radial lip seals designs vary depending on whether seal is to be used with grease- or oil-lubricated (packings, bearings).

e. Mechanical seals have a (clamp, spring) to force the seal in place.

f. Ring seals may also have a backup ring for (excess pressure, high temperatures).

Objective 5

Match the parts of a lip seal with their descriptions.

1. Garter spring
2. Inner shell (case)
3. Outer shell (case)
4. Primary lip
5. Sealing element
6. Secondary lip

_____ a. Short, non-spring-loaded part used to exclude contaminants; faces opposite direction of primary lip

____ b. Flexible elastomeric "working" component that rides against the shaft

____ c. Outer, cup-shaped, rigid structure that acts as a protective cover for the sealing element and holds the installed seal in place

____ d. Flexible elastomeric part that contacts the rotating surface

____ e. Coiled wire spring with its ends connected; used for maintaining a sealing force between the sealing element and sealing surface

Objective 6

Complete statements concerning common materials for seals by circling the correct answers.

a. Fluoroelastomers (are, are not) compatible with a wide range of fluids that destroy other synthetics.

b. A disadvantage of (nitrile, felt) is that it absorbs water, which may cause shaft rusting.

c. P.T.F.E. (Teflon®) has (poor, excellent) resistance to most chemicals, including hydrocarbons and oxygenated blends.

d. (Nitrile, Silicone) is generally red, orange, gray, or blue.

e. Nitrile has (poor, excellent) compatibility to some synthetic oils and extreme pressure (EP) lubes.

f. (Leather, Polyacrylate) has good dry-running capabilities and is compatible with most lubes and solvents.

g. (Polyacrylate, Nitrile) is the most common material used today for seals.

h. (Nitrile, Fluoroelastomer) is considered expensive.

Written Test

Objective 7

Distinguish between types of packing by placing:

- C = next to compression packings
- M = next to molded compression packings

_____ a. Available as a "rope" or partially performed sections

____ b. May be U-, V-, or ring-shaped

____ c. Commonly made of rubber, neoprene, or other rigid synthetic material

____ d. Creates a seal when squeezed into place

____ e. Open side is installed towards fluid pressure

Objective 8

Describe two causes of sealing failure.

a. ____

____

b. ____

____

Objective 9

Complete statements concerning guidelines for installing seals by filling in the blanks with the correct answers.

a. Check and adjust the ____________________ after installing a seal, and check for leaks.

b. Make sure the new seal faces in the correct direction; usually the ____________________ faces the lubricant or fluid to be retained.

c. Check shaft and bore dimensions to make sure they match the ____________________.

d. Excessively worn or grooved shafts may be fitted with ____________________ to create a new seal running surface.

e. When installing ____________________, make sure it is firmly seated and compacted in the groove according to the seal manufacturer's directions.

f. Name one correct tool used to install seals. ____________________

Objective 10

Distinguish between types of gaskets by placing:

- F = next to formed gaskets
- FP = next to formed-in-place gaskets

_____ a. Made from various solid materials and come in a variety of shapes and sizes

____ b. Made from various chemicals

____ c. Made to fit the shape and hole arrangement by the manufacturer or cut to fit by the installer

____ d. Used increasingly where paper and cork gaskets were previously used

____ e. May be sprayed on, brushed on, or applied with a spatula or putty knife out of a tube.

Objective 11

Describe two common gasket materials and their uses.

a. ____

____

b. ____

____

Objective 12

Select true statements concerning guidelines for installing gaskets by placing a "T" in the blanks next to true statements and an "F" next to false statements.

_____ a. If a gasket leaks, fill the holes with putty and reuse it.

____ b. Hand-start fasteners, then tighten in the recommended torque sequence to correct torque.

____ c. Formed gaskets should be reused.

____ d. A badly bent formed gasket can be corrected without damaging the gasket.

____ e. Use a low-volatile RTV on equipment having oxygen sensors and use it sparingly.

____ f. Store gaskets flat in the packages and away from extreme temperatures and humidity.

____ g. The curing time for RTV sealers is about 20 minutes and 30 minutes for anaerobic sealers.

Written Test

Objective 13

List two functions of bearings.

a. ______________________________

b. ______________________________

Objective 14

Distinguish between basic categories of bearings by placing:

- F = next to friction or plain bearing
- A = next to antifriction bearing

_____ a. Advantages—Low cost, quiet operation, requires less space

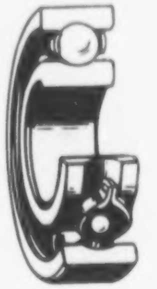
____ b. Provides a **rolling** contact between mating surfaces

____ c. Disadvantages—Higher cost, noisier operation, requires more space

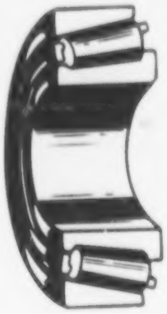
____ d. Provides a **sliding** contact between mating surfaces

Objective 15

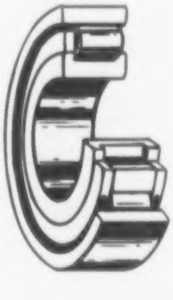
Identify major types of bearings. Write your answers in the blanks provided.



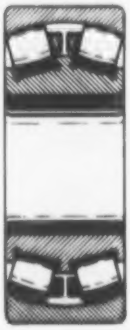
a. ____________________



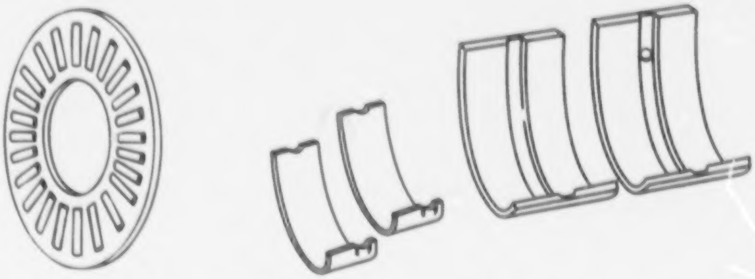
b. ____________________



c. ____________________



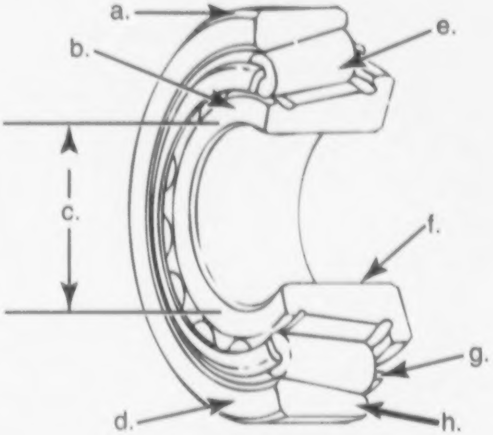
d. ____________________



e. ______________________ f. ______________________

Objective 16

Identify parts of an antifriction bearing. Write your answers in the blanks provided.



Used with permission of Deere and Company, Moline, Illinois.

a. ______________________ b. ______________________

c. ______________________ d. ______________________

e. ______________________ f. ______________________

g. ______________________ h. ______________________

Written Test

Objective 17

Distinguish between basic load forces on bearings by placing:

- A = next to axial or thrust load forces
- R = next to radial load forces

_____ a. Directed endways or horizontal to the shaft

____ b. Directed sideways or perpendicular to the shaft

Objective 18

List two conditions that determine load-carrying capacity of bearings.

a. ______________________________

b. ______________________________

Objective 19

Select common materials used for bearings from the following list by placing an "X" in the appropriate blanks.

_____ a. Synthetic rubbers and plastics

____ b. Cloth

____ c. Steel alloys

____ d. Wood

____ e. Leather

____ f. Nickel

____ g. Babbit

Objective 20

List four reasons for bearing failure.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Objective 21

Distinguish between correct and incorrect bearing maintenance procedures by placing a "C" for correct and an "I" for incorrect in the appropriate blanks.

____ a. Work with clean approved tools in clean surroundings.

____ b. Clean outside of housings before exposing bearings.

____ c. Handle bearings with work gloves.

____ d. Work on the floor.

____ e. Support bearing when removing it from shaft.

____ f. Treat a used bearing as carefully as a new one, until the used one is proven to be defective.

____ g. Protect disassembled bearings from dirt and moisture.

____ h. Wipe bearings, if necessary, only with greasy rags.

____ i. Clean the inside of housings before installing bearings.

____ j. Wash new bearings before installation.

____ k. Keep lubricants clean when applying them, and cover the containers when not in use.

____ l. Spin all bearings with compressed air.

____ m. Use the same container for both cleaning and final rinse of used bearings.

____ n. Use the correct type and amount of lubricant.

Objective 22

List two external items and two internal items to look for when inspecting bearings.

a. External

- ______________________________
- ______________________________

a. Internal

- ______________________________
- ______________________________

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 7
b. 16
c. 6
d. 12
e. 14
f. 9
g. 10
h. 8
i. 15
j. 2
k. 17
l. 4
m. 13
n. 11

Objective 2

Any two of the following:

a. To retain lubricants or liquids
b. To exclude dirt, water, and other contaminants
c. To separate dissimilar fluids (such as lubricating oil and water)
d. To confine pressure

Objective 3

a. S
b. D
c. D
d. S

Objective 4

a. Ring
b. Radial lip
c. Mechanical
d. Bearings
e. Spring
f. Excess pressure

Objective 5

a. 6
b. 5
c. 3
d. 4
e. 1

Objective 6

a. Are
b. Felt
c. Excellent
d. Silicone
e. Poor
f. Leather
g. Nitrile
h. Fluoroelastomer

Answers to Written Test

Objective 7

a. C
b. M
c. M
d. C
e. M

Objective 8

Any two of the following (in student's own words):

a. **Improper installation techniques or careless handling**—Could result in nicked or cut sealing surfaces, scratched shaft, distorted or cocked seal, or damaged garter spring
b. **Incorrect seal used for application**
   - Includes seals that are the wrong size; that are used in systems with excessive speeds, temperatures, or pressures; or that use fluids incompatible with the sealing material
   - Could result in seals that are brittle, cracked, hardened, excessively worn, spongy, or blown-out
c. **Misalignment of shaft to bore**—Commonly results in excessive wear on one side of the seal
d. **Shaft or bore excessive roughness, scratches, burrs, or dirt**—Can result in excessive wear to the shaft, bore, and/or seal

Objective 9

a. Fluid level
b. Lip
c. Seal specifications
d. Wear (repair) sleeves
e. Packing
f. Any one of the following: soft-face hammer, specially-made seal installer, old bearing cup, or arbor press

Objective 10

a. F
b. FP
c. F
d. FP
e. FP

Objective 11

Any two of the following (in student's own words):

a. **Paper gaskets**—Used on water outlets, water pumps, timing covers, fuel pumps, and some carburetors
b. **Neoprene (synthetic rubber) gaskets**—Used with valve covers, which are periodically removed for valve adjustments; are reusable
c. **Cork gaskets**—Commonly used as valve cover, transmission, and engine oil pan gaskets; limited use because of their brittleness and tendency to shrink
d. **Steel gaskets**—Used in high temperature areas; some head gaskets are made of steel
e. **Asbestos/combination gaskets**—Made with asbestos or other heat-resistant material; used in high-temperature areas
f. **Teflon® gaskets**—Used in high-temperature areas

Objective 12

a. F
b. T
c. F
d. F
e. T
f. T
g. F

Objective 13

Any two of the following (in student's own words):

a. Support the moving part
b. Reduce friction
c. Reduce wear
d. Provide a replaceable wear surface

Objective 14

a. F
b. A
c. A
d. F

Objective 15

a. Ball antifriction bearing
b. Tapered roller antifriction bearing
c. Straight roller antifriction bearing
d. Spherical roller (barrel roller) antifriction bearing
e. Thrust-load needle antifriction bearing
f. Split friction or plain bearing

Objective 16

a. Outer race
b. Inner race
c. Bore
d. Face
e. Roller
f. Cone
g. Separator
h. Cup

Objective 17

a. A
b. R

Objective 18

Any two of the following:

a. Size of bearing
b. Number of rolling elements
c. Type of races

Answers to Written Test

Objective 19

a, c, f, g

Objective 20

Any four of the following:

a. Dirt
b. Improper assembly
c. Misalignment
d. Insufficient lubrication or inferior lubricants
e. Overloading
f. Corrosion
g. Inferior material
h. Incorrect grooving
i. Incorrect clearance

Objective 21

a. C
b. C
c. I
d. I
e. C
f. C
g. C
h. I
i. C
j. I
k. C
l. I
m. I
n. C

Objective 22

a. **External**—Any two of the following:

- Cracked races
- Dented seals
- Broken or damaged separators
- Broken or damaged balls or rollers
- Brownish blue or bluish black color caused by overheating

b. **Internal**—Any two of the following:

- Pitted, scratched, or flaked balls, rollers, and races on separable bearings
- Visible pits or scratches on nonseparable bearings
- Clicking or sticking when outer race is rotated

Prerequisites:
1-B, 2-B

Learning Activities Sheet

Student Name ____________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 9.

☐ 4. **View** Different types of seals, packings, gaskets, and sealants, and special tools that may be used to remove seals and bearings.

☐ 5. **Observe** Demonstration of procedures to be used in completing Job Sheets 1 and 2.

☐ 6. **Do** Job Sheet 1, "Install a Radial Lip Seal," and Job Sheet 2, "Remove and Install an Engine Oil Seal and Wear Sleeve."

☐ 7. **Stop** Have instructor evaluate your performance on each procedure, and if the evaluations are satisfactory, continue to step 8. If either evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedures outlined in Job Sheets 1 and 2, and repeat steps 6 and 7.

☐ 8. **Observe** Demonstration of procedure to be used in completing Job Sheet 3.

☐ 9. **Do** Job Sheet 3, "Install a Packing."

☐ 10. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 3, and repeat steps 9 and 10.

Learning Activities Sheet

☐ 11. **Study** Information Sheet, Objectives 10 through 12.

☐ 12. **Observe** Demonstration of procedure to be used in completing Job Sheet 4.

☐ 13. **Do** Job Sheet 4, "Replace a Formed Gasket."

☐ 14. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 4, and repeat steps 13 and 14.

☐ 15. **Observe** Demonstration of procedure to be used in completing Job Sheet 5.

☐ 16. **Do** Job Sheet 5, "Replace a Formed In-Place Gasket."

☐ 17. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 5, and repeat steps 16 and 17.

☐ 18. **Study** Information Sheet, Objectives 13 through 22.

☐ 19. **View** Different types of bearings, and compare friction bearings and antifriction bearings.

☐ 20. **Observe** Demonstration of procedure to be used in completing Job Sheet 6.

☐ 21. **Do** Job Sheet 6, "Remove and Install a Camshaft Friction Bearing."

☐ 22. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 23. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 6, and repeat steps 21 and 22.

☐ 23. **Observe** Demonstration of procedures to be used in completing Job Sheets 7 and 8.

☐ 24. **Do** Job Sheet 7, "Remove and Install an Antifriction Bearing," and Job Sheet 8, "Clean and Pack an Antifriction Bearing."

☐ 25. **Stop** Have instructor evaluate your performance on each procedure and if the evaluations are satisfactory, continue to step 26. If either evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedures outlined in Job Sheets 7 and 8, and repeat steps 24 and 25.

☐ 26. **Check** With instructor for any additional assignments to be completed.

☐ 27. **Do** Additional assignments listed below.

____

____

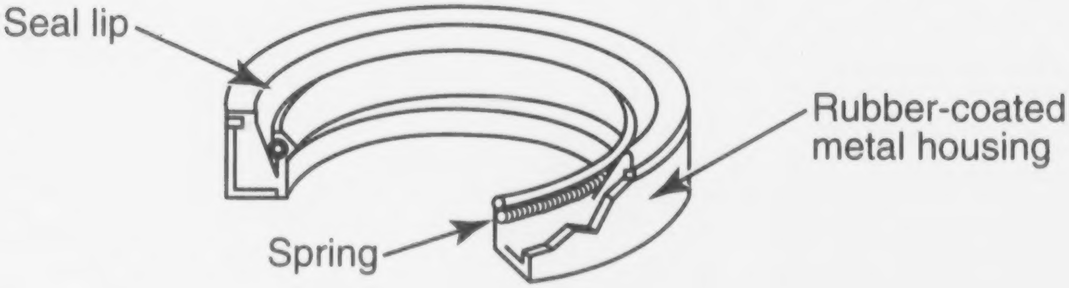
____

☐ 28. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

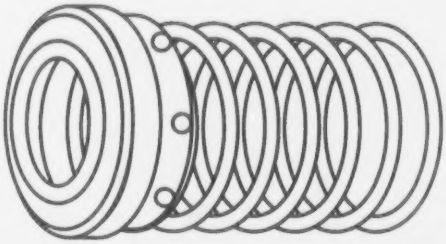
☐ 29. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

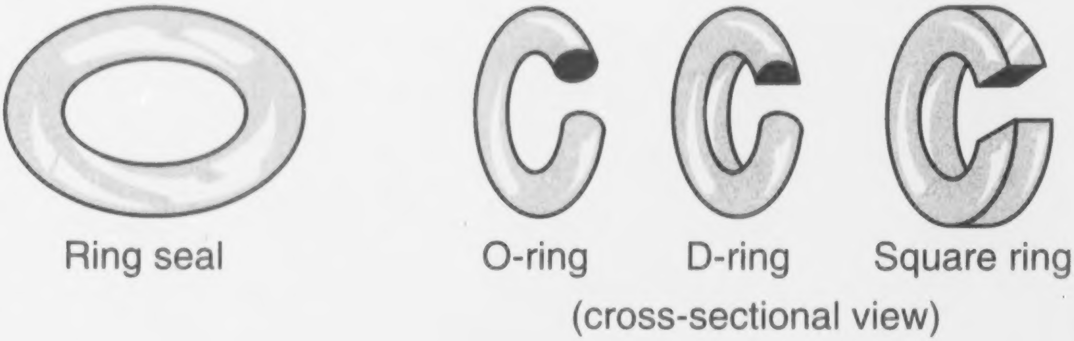
Common Seals


Seal lip
Rubber-coated metal housing
Spring

Radial Seal

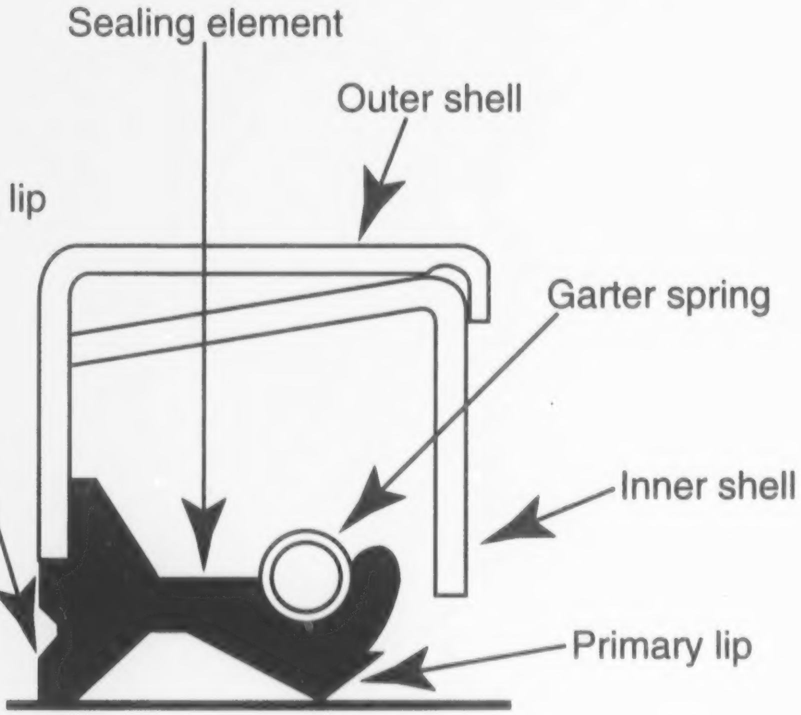


Mechanical Seal


Ring seal
O-ring
D-ring
Square ring
(cross-sectional view)

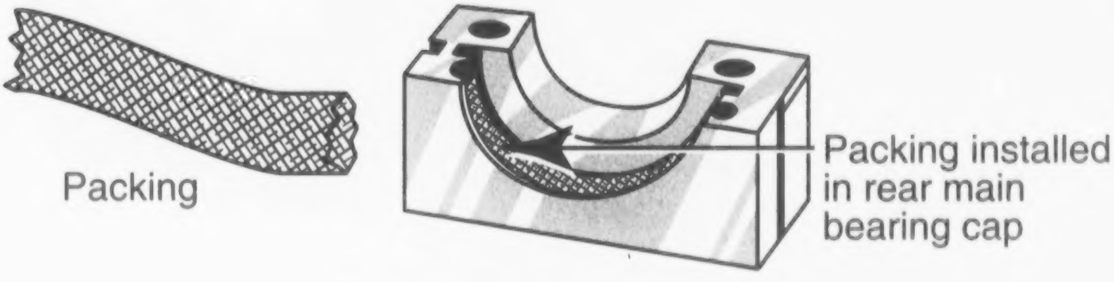
Ring Seals

Parts of a Lip Seal

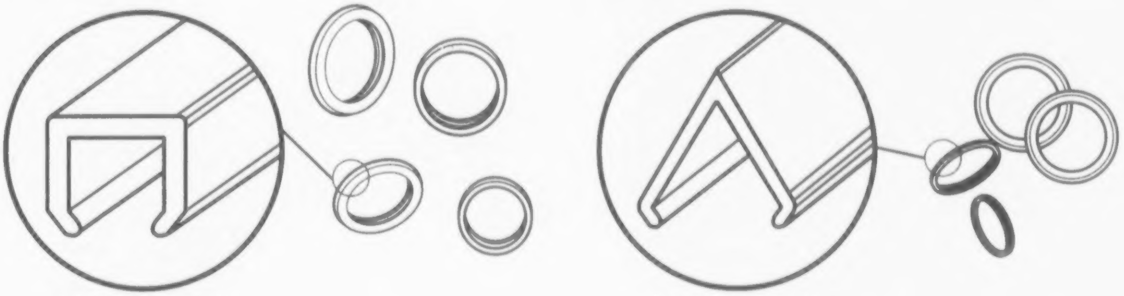

Sealing element
Outer shell
Sealing lip
Garter spring
Inner shell
Primary lip

Drawing courtesy of Chicago-Rawhide

Types of Packings

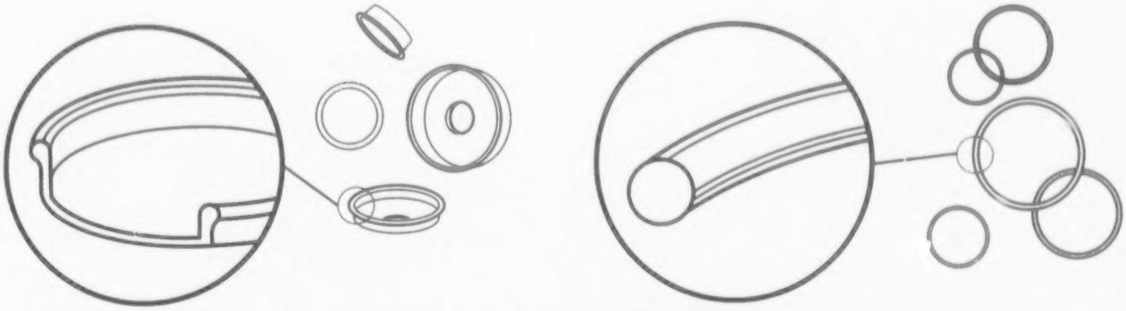

Packing
Packing installed in rear main bearing cap

Compression Packings



U-shaped

V-shaped

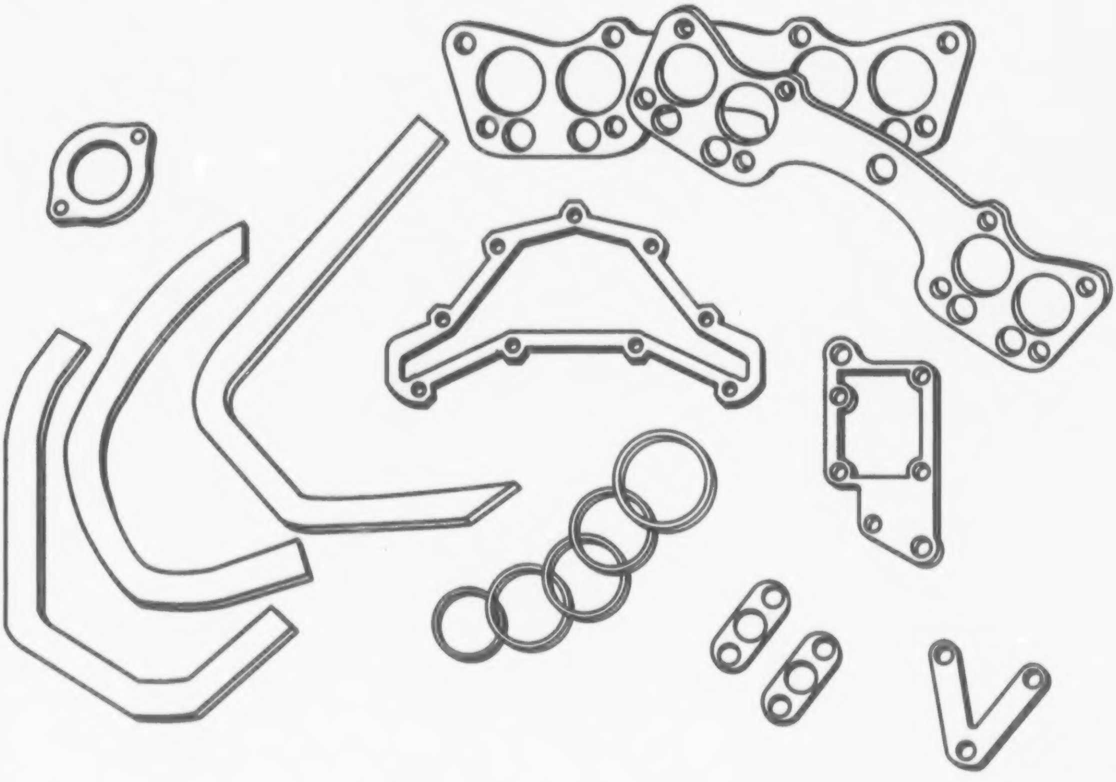


Cup-shaped

Ring-shaped

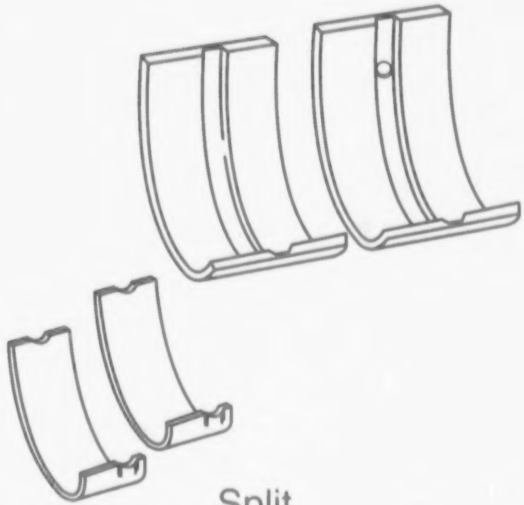
Molded Compression Packings

Examples of Gaskets

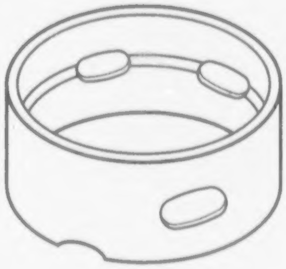


Major Types of Bearings

Friction or Plain Bearings

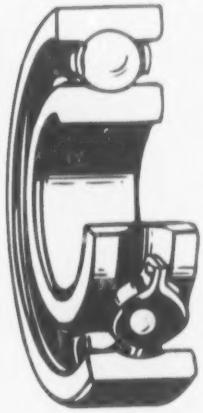


Split

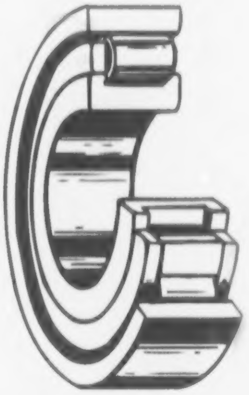


Sleeve or Plain Bushing

Antifriction Bearings



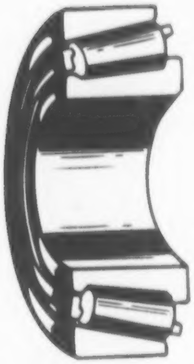
Ball



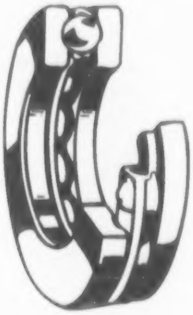
Straight Roller

Major Types of Bearings
(Continued)

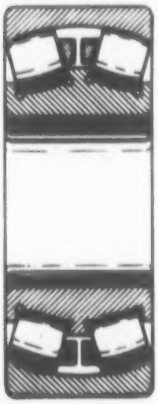
Antifriction Bearings



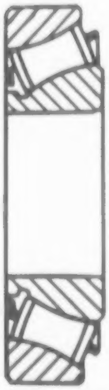
Tapered Roller



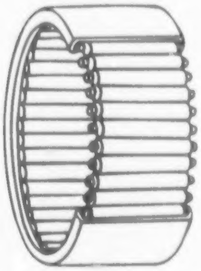
Ball-thrust



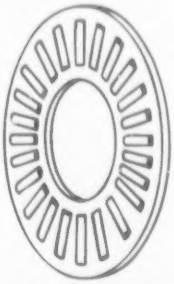
Spherical Roller



Concave Roller

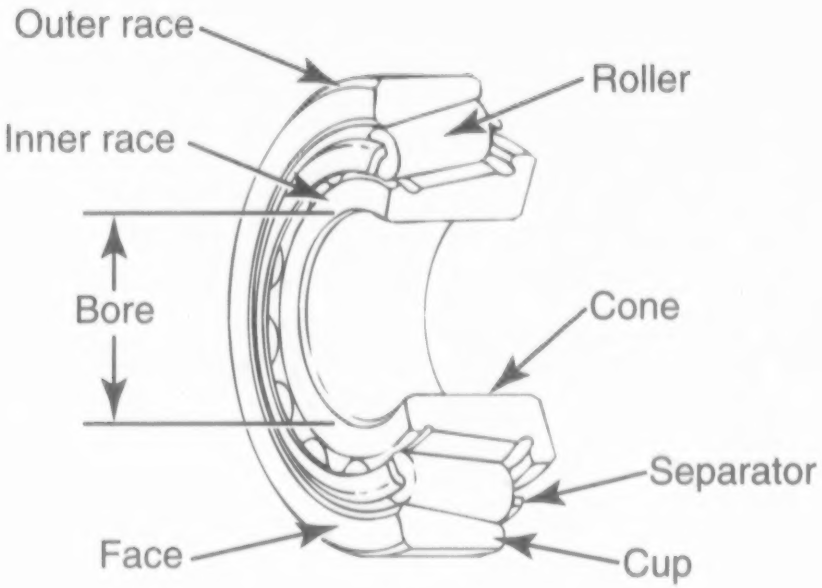


Radial-load Needle



Thrust-load Needle

Parts of an Antifriction Bearing


Outer race
Roller
Inner race
Bore
Cone
Separator
Face
Cup

Courtesy of Deere and Co.

Unit 4-B Fluids and Lubricants

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 4B-3

Written Test 4B-9

Answers to Written Test 4B-23

Learning Activities Sheet 4B-29

Transparency Masters

1—Common Types of Filters 4B-31
2—Locations of Filters in Hydraulic Systems 4B-33
3—Types of Filter Circuits in Hydraulic Systems 4B-35

Student Components

Student Page

Objective Sheet 4B-3

Information Sheet 4B-5

Student Supplement

1—API Engine Oil Classification 4B-23

Job Sheets

1—Test for Combustion Leakage into a Cooling System 4B-25
2—Test for Air in a Cooling System 4B-27
3—Clean a Cooling System 4B-29
4—Change Oil and Oil Filter 4B-33

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the student supplement. Explain to students how you plan to evaluate the supplement, if at all.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Discuss the hazards associated with some fluids and lubricants, and explain appropriate safety procedures.
- Show examples of the different types of filters used on diesel equipment. Point out the different characteristics, and discuss where these would normally be used.
- Show examples of fluid additives, and discuss why they are used.
- Discuss fluid contaminants and the problems they cause. Also discuss how they can be prevented.
- Show the various fluid systems used on diesel equipment. Discuss how the systems are similar (components) and how they are different (arrangements and fluids used).
- Show examples of the following fluids and lubricants commonly used on diesel equipment:
    - Grade 1 and 2 diesel, as well as any alternative fuels available
    - Coolants and antifreeze
    - Engine oils
    - Transmission fluids
    - Gear oils and lubricants
    - Power steering fluids
    - Hydraulic fluids
    - Chassis lubricants and grease

  Point out the differences such as color, feel, smell, etc., as well as explaining where these would be used.
- Discuss and demonstrate common maintenance procedures required on fluid and lubricant systems.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper.* Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- *Diesel Fuels for the Nineties: Composition and Additives to Meet Emissions and Performance Needs.* Society of Automotive Engineers, Inc., 1993.
- Espenschied, Roland. *Diesel Engines: Careers, Service, Maintenance.* Athens, GA: American Association for Vocational Instructional Materials, 1990.
- *Fundamentals of Service: Engines.* Moline, IL: Deere and Company, 1991.
- *Fundamentals of Service: Fuels, Lubricants, and Coolants.* Moline, IL: Deere and Company, 1992.
- *Introduction to Automotive Service.* Stillwater, OK: Curriculum and Instructional Material Center/Oklahoma Department of Vocational and Technical Education, 1989.

Suggested Supplemental Resources

Print Media

- *Straight Talk About Motor Oil* teaching unit (includes videotape, brochures, photocopy master sheets, quiz, and wall chart.) Available from:

  Valvoline, Inc.

  P.O. Box 14045

  Lexington, KY 40512-4045

  606-264-7535

- *Lubricating Oil Systems—Troubleshooting* (3387003)
- *Cooling Systems—Troubleshooting* (3387030)
- *Lubrication and Filtration* (3387113)
- *Coolant Additives and Filtration* (3387251)

The above are all available as books, slide sets, or audio tapes from your local Cummins Engine Company dealer/distributor or call:

Cummins Engine Company Customer Relations
800-345-5654 or 502-453-8549 or for more information call 800-DIESELS

- *Principles of Lubrication* (SEBV0567), 24-page book. (1991). Available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

- *Heavy Duty Service Manual for Air and Liquid Filtration.* Book contains basic information on types of filtration systems including air and oil, hydraulics, air filter housings, and pre-cleaners. Available from:

  Fram Division/Allied Corporation
  Heavy Duty/Training Department
  105 Pawtucket Avenue
  East Providence, RI 02916
  401-434-7000

Electronic Media

- *FOS Fuels, Lubricants, and Coolants* set of 72 slides (FOS5807S-152). Available from:

  Deere & Company
  Distribution Service Center
  P.O. Box 186
  Moline, IL 61266-1086

Written Test

Name ____

Date ______________________________ Score ____________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Aeration
2. Additives
3. American Petroleum Institute (API)
4. American Society for Testing and Materials (ASTM)
5. Antifreeze
6. Ash
7. Contaminant
8. Coolant
9. Filter
10. Friction
11. Gallery
12. Inhibitor
13. Micron
14. MIL
15. Particulate
16. Permanent antifreeze
17. Strainer
18. Viscosity
19. Volatile

_____ a. Association that establishes standard test methods, specifications, and recommended practices for various materials, products, and services

____ b. Substance made up of minute separate particles

____ c. Material added to coolant to prevent freezing

____ d. Measure of a fluid's resistance to flow (at a given temperature)

____ e. Liquid solution containing properties that will not readily boil away

____ f. Device that removes contaminants from fluids or lubricants

____ g. Coarse filter usually designed to prevent large items such as rocks and bolts from entering the system

____ h. Any unwanted material in a fluid or lubricant

____ i. Mixture of air and water

____ j. Solid residue (non-burnable) left when combustible material (such as oil) is burned or oxidized

____ k. Pipe or passageway in the engine used to carry engine oil from one area to another

____ l. Chemical that dissolves in water to form a rustproof film on metal

____ m. Liquid that absorbs and transfers heat to maintain normal engine operating temperature

____ n. Readily changed from liquid to vapors at a relatively low temperature

____ o. Resistance to movement between any two objects placed in contact with each other

Objective 2

Distinguish between true and false statements concerning fluid safety rules by placing a "T" next to true statements and an "F" next to false statements.

____ a. Avoid contact with hot objects such as exhaust manifolds.

____ b. Avoid contact with skin or eyes.

____ c. Allow the system to warm up before working on it.

____ d. Wear safety glasses when entering a fluid system at any point.

____ e. Remove filter caps and pressure caps quickly to relieve any trapped pressure.

____ f. Since many fluids are flammable, treat all fluids as flammable materials.

Objective 3

Match the basic components of fluid systems with their functions.

1. Filter
2. Fluid
3. Lines
4. Pump
5. Reservoir

____ a. Does the work that system is intended to perform

____ b. Moves the fluid through the system

____ c. Holds the amount of fluid needed for the system to operate correctly

____ d. Convey the fluid to and from the system's parts

____ e. Removes dirt, metal particles, and rust and corrosion from the system fluid or prevents foreign objects from entering system components

Objective 4

Distinguish among the common types of filters by placing:

- C = next to cartridge filters
- SO = next to spin-on filters
- S = next to strainer filters

_____ a. Are located at inlets to components (such as oil pans or fuel tanks) to prevent objects such as nuts, bolts, and metal chips from entering the component

____ b. Have a single surface that catches and removes dirt particles larger than the holes in the filter; the surface is made of specially treated micrometric cellulose paper; the fluid passes straight through its tiny holes

____ c. Use a large volume of filter material (usually pleated paper) to trap the particles as the oil passes through

Objective 5

Match the common additives to fluids with their functions.

1. Anti-foam compounds
2. Anti-oxidation compounds
3. Anti-wear compounds
4. Corrosion inhibitors
5. Viscosity index improvers

_____ a. Help reduce wear on parts

____ b. Help reduce corrosion of parts

____ c. Help reduce rust

____ d. Keep oils at a consistent viscosity in extreme temperatures

____ e. Help reduce aeration of fluids

Objective 6

Select the effects of contaminants in fluid systems from the following list by placing an "X" in the appropriate blanks.

_____ a. Poor performance

____ b. Clogged external passages

____ c. Seized components

____ d. Improper operation

____ e. Scored external surfaces resulting in excess leakage and poor performance

____ f. Increased component life

Written Test

Objective 7

Discuss three practices for ensuring fluid system cleanliness.

a. ____________________

b. ____________________

c. ____________________

Objective 8

List four applications of fluid systems on diesel/heavy duty equipment.

a. ____________________

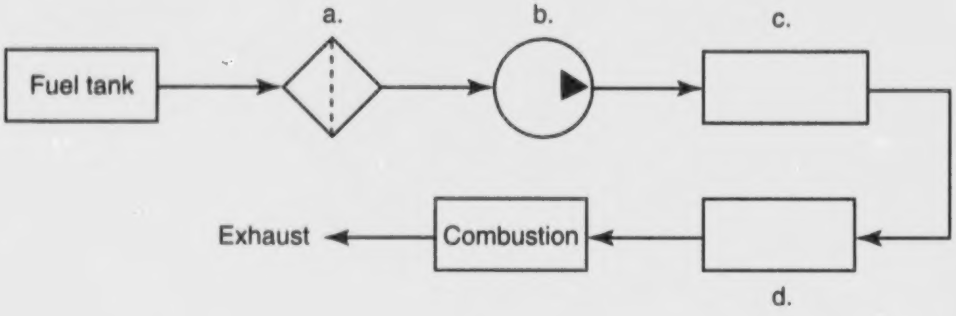
b. ____________________

c. ____________________

d. ____________________

Objective 9

Label the diagram showing the flow of fuel through the fuel system.



a. ____________________

b. ____________________

c. ____________________

d. ____________________

Objective 10

Distinguish between grades of diesel fuel used on diesel/heavy duty equipment by placing a:

- "1" next to Grade 1 diesel fuel
- "2" next to Grade 2 diesel fuel

_____ a. Is less volatile

____ b. Used in extremely cold conditions—temperatures below 0°F—or when there are wide variations in loads and speeds

____ c. Is less viscous so it remains thin at lower temperatures

____ d. Produces more power

Objective 11

Complete statements concerning alternative fuels that may be used on diesel/heavy duty equipment by filling in the blanks with the correct answers.

a. Efforts to reduce the ____________________ released into the atmosphere by motor vehicles and heavy equipment have led to the search for alternatives to diesel fuel.

b. Many new ____________________ have taken effect in the 1990s, and as environmental regulations continue to become stricter, the use of alternative fuels will grow.

c. ____________________ is plentiful and cleaner than diesel fuel. It must be compressed (CNG) and stored under pressure in a compressed gas cylinder or cooled to –258°F to be stored in its liquid form (LNG).

d. ____________________ is a clean fuel coming into wider use, especially in agricultural equipment.

Objective 12

Select from the following list the correct purpose of a cooling system by placing an "X" next to the appropriate answer.

_____ a. To increase fuel economy

____ b. To reduce wear and corrosion

____ c. To keep an engine's temperature within its acceptable temperature range

Written Test

Objective 13

Distinguish between effects of a malfunctioning cooling system by placing:

- "H" = next to effects of running too hot
- "C" = next to effects of running too cold

_____ a. Poor fuel economy

____ b. Scoring of parts

____ c. Knocking

____ d. Lubrication failure

____ e. Accumulation of water and sludge in the crankcase

____ f. Seizure of moving parts

____ g. Burned pistons and valves

Objective 14

Match the parts of a liquid cooling system with their functions.

1. Coolant
2. Coolant filter
3. Expansion tank
4. Fan
5. Fan belt
6. Hoses
7. Pressure cap
8 Radiator
9. Thermostat
10. Water pump

_____ a. Provides a reservoir for the engine's coolant and releases heat into the atmosphere when the engine is operating

____ b. Medium that carries excess heat from the engine

____ c. Circulates coolant through the system

____ d. Flexible connections between the engine and other parts of the cooling system

____ e. Controls the flow of coolant to the radiator to maintain correct operating temperatures

____ f. Relieves pressure from system as coolant heats, lets in air pressure as coolant cools

____ g. Transmits power from engine crankshaft to drive fan and water pump

____ h. Forces cooling air through radiator core to more quickly dissipate heat

Objective 15

Complete statements concerning liquid cooling systems in diesel/heavy duty equipment by filling in the blanks with the correct answers.

a. Use a coolant that is a solution of water and an antifreeze made of ____________________ with chemical additives.

b. Typically the ratio of water to antifreeze is ____________________.

c. Too high a percentage of antifreeze (more than 65%) raises the coolant's ____________________ point and lessens its cooling properties.

d. Always consult the antifreeze maker's instructions and the ____________________ for the specific recommended ratios.

Objective 16

List three characteristics of a good antifreeze.

a. ____

b. ____

c. ____

Objective 17

Complete statements concerning the importance of engine lubrication by filling in the blanks with the correct answers.

a. Proper lubrication with the correct oil is critical to the ____________________ and ____________________ of an engine.

b. Allowing the oil pressure to fall too low, using the wrong oil, or not changing the oil at recommended intervals can ____________________.

Objective 18

List three functions of engine oil.

a. ____

b. ____

c. ____

Objective 19

Match the parts of the engine lubrication system with their functions. Definitions continue on the next page.

1. Oil cooler
2. Oil filter
3. Oil gallery
4. Oil pan
5. Oil pump
6. Pressure gauge
7. Pressure regulating valve
8. Thermostat

_____ a. Provides a reservoir for the engine oil

_____ b. Helps dissipate the heat from the engine oil

____ c. Limits the maximum oil pressure

____ d. Allows for rapid warm-up during initial engine run periods

____ e. Carries engine oil from one area to another

____ f. Moves oil from the oil pan through a filter and on to all parts that need to be oiled

____ g. Indicates oil pressure during engine operation

____ h. Removes abrasive materials from the oil

Objective 20

List four characteristics of a good engine oil.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

Objective 21

Complete statements concerning viscosity by circling the correct answers.

a. Oils vary in viscosity as the (temperature, humidity) changes.

b. Oil becomes (less, more) fluid as the temperature rises.

c. (Lower, Higher) viscosity numbers correspond to greater viscosity.

d. Specifications are determined by the time in seconds of flow through a/an (viscometer, oil meter)

e. (Lighter, Heavier) oils for winter use are specified at 0°F and carry a 5W, 10W, or 20W symbol.

f. (Lighter,) Heavier) oils are specified at 210°F and carry a 20, 30, 40, or 50 viscosity number.

g. (Multigrade, Generic) oils behave as lighter oils at low temperatures and as heavier oils at high temperatures.

Objective 22

Complete statements concerning the API classification system by filling in the blanks with the correct answers.

a. Represents a joint effort of API, SAE, and ASTM to clarify and standardize ____________________.

b. Indicates specifically the type of ____________________ that the oil provides and the applications for which it is appropriate.

c. Diesel equipment uses Class ____________________ oils.

Objective 23

Discuss three oil maintenance procedures.

a. ____

b. ____

c. ____

Objective 24

Complete statements concerning fluids/oils for transmissions and gearboxes by filling in the blanks with the correct answers.

a. A function of manual transmission oil is to allow ____________________ to move more easily.

b. Another function of manual transmission oil is to cushion the shock between ____________________ and other parts that contact one another.

c. Manual transmission oil cools ____________________ in the transmission.

d. Transmission oil serves the same primary purposes as ____________________.

e. List two of the lubricants used in manual transmissions:

- ____________________
- ____________________

f. In manual transmission oil maintenance use only oils of the ____________________ specified by the equipment manufacturer.

g. Inspect the transmission regularly for ____________________.

h. Automatic transmission fluid contains a ____________________ dye to distinguish it from other oils.

i. Two common types of ATFs are:

- ____________________
- ____________________

j. In ATF maintenance, check fluid regularly with engine idling, transmission in ____________________, and oil temperature between 160°F and 200°F.

k. One common type of gear lubricant is ____________________.

Objective 25

Distinguish between true and false statements concerning fluids for power steering by placing a "T" next to true statements and an "F" next to false statements.

_____ a. Heavy duty equipment may have either air-assisted or hydraulic-assisted power steering.

____ b. The hydraulic fluid reservoir might be either a separate component or it might be within the pump assembly.

____ c. Hydraulic-assisted power steering is a hydraulic system that employs an open hydraulic circuit.

____ d. Automatic transmission fluid may be used in power steering systems.

____ e. Check fluid level and inspect system for leaks once a year.

Objective 26

Select from the following list of appropriate locations of filters in hydraulic systems by placing an "X" in the blanks next to the true statements.

_____ a. Oil filter

____ b. Pressure line filter

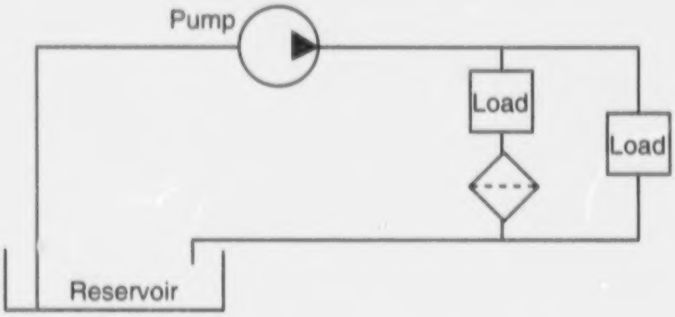
____ c. Return line filter

____ d. Air filter

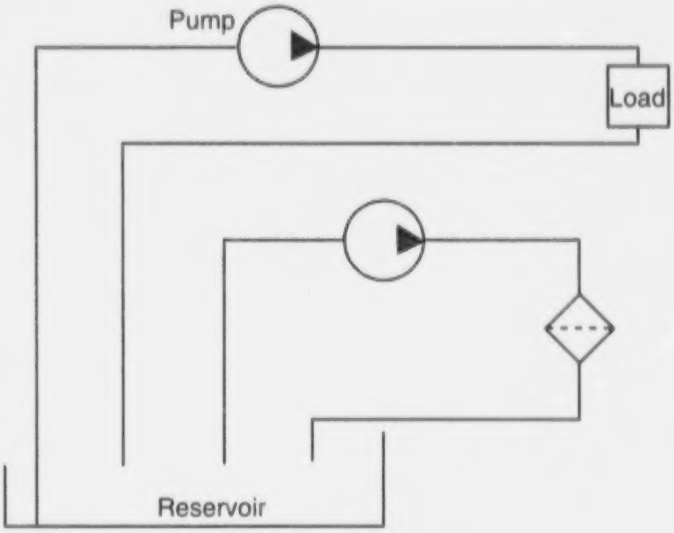
____ e. Strainer or suction line filter

Objective 27

Identify the types of filter circuits in hydraulic systems. Write your answers in the blanks provided.


Pump
Load
Load
Reservoir

a. ______________________


Pump
Load
Reservoir

b. ______________________

Written Test

Objective 28

Complete statements concerning chassis lubrication systems by circling the correct answers.

a. On-board lubrication systems are used on diesel equipment to (eliminate, increase) the need to manually grease each individual lubrication point.

b. Manual on-board lubrication systems have a single fitting on the (axle, manifold).

c. Automatic chassis lubrication systems add a grease (filter, reservoir) and an electric motor- or air-driven pump to the basic on-board lubrication system.

d. An ACLS lubricates the chassis and suspension (less, more) effectively than a manual system.

Objective 29

Complete statements concerning chassis grease by filling in the blanks with the correct answers.

a. One element of chassis grease is ____________________.

b. One characteristic of satisfactory grease is ____________________.

Objective 30

Discuss two maintenance rules of chassis lubrication systems.

a. ____

____

____

b. ____

____

____

Objective 31

Complete statements concerning batteries by filling in the blanks with the correct answers.

a. The ____________________ in batteries is vital to their generating sufficient electrical power.

b. The ____________________ in conventional batteries should be just below the bottom of the vent opening.

c. Check batteries regularly and add ____________________ when needed.

d. Maintenance-free batteries are ____________________ and never need additional water.

e. Inspect batteries regularly for ____________________.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 4
b. 15
c. 5
d. 18
e. 16
f. 9
g. 17
h. 7
i. 1
j. 6
k. 11
l. 12
m. 8
n. 19
o. 10

Objective 2

a. T
b. T
c. F
d. T
e. F
f. T

Objective 3

a. 2
b. 4
c. 5
d. 3
e. 1

Objective 4

a. S
b. C
c. SO

Objective 5

a. 3
b. 4
c. 2
d. 5
e. 1

Objective 6

a, c, d

Objective 7

Any three of the following practices (in student's own words):

a. Chance fluids and filters regularly.
b. Fill systems only with clean fluids.
c. Clean dirt off breather caps and filter plugs before opening the system.
d. Use clean, lint-free towels to wipe dipsticks.
e. Replace worn seals and gaskets to keep dirt from entering the system.
f. Keep work area clean.

   Note: This is especially important when disassembling components such as pumps.

g. Clean and flush components before installing them in the system.

Answers to Written Test

Objective 8

Any four of the following applications of fluid systems on diesel/heavy duty equipment:

a. Power—Heavy duty equipment generates its power from various fuels, most commonly diesel fuel.
b. Cooling—Heavy duty equipment engines may be either air cooled or liquid cooled to keep operating temperatures within acceptable ranges.
c. Engines—Engine oils lubricate the moving parts in an engine, protect them from rust and corrosion, and work with the cooling system to keep the engine from overheating.
d. Transmissions—Transmission fluids are critical to the functioning of both manual and automatic transmissions.
e. Gears—All of the gears in a piece of heavy duty equipment's various components and systems must be properly lubricated to function properly without being damaged.

Objective 9

a. Fuel filter
b. Fuel pump
c. Fuel injectors
d. Cylinders

Objective 10

a. 2
b. 1
c. 1
d. 2

Objective 11

a. Pollutants
b. Emissions standards
c. Methane
d. Propane

Objective 12

c

Objective 13

a. C
b. H
c. H
d. H
e. C
f. H
g. H

Objective 14

a. 8
b. 1
c. 10
d. 6
e. 9
f. 7
g. 5
h. 4

Objective 15

a. Either ethylene glycol or propylene glycol
b. 1:1
c. Freezing
d. Service manual

Objective 16

Any three of the following:

a. Prevents freezing
b. Inhibits rust and corrosion
c. Is chemically stable
d. Flows readily at all temperatures
e. Resists foaming
f. Does not conduct electricity

Objective 17

a. Performance, life
b. Destroy an engine

Objective 18

Any three of the following:

a. Allows parts to move more easily
b. Cushions impact between parts
c. Dissipates heat from the engine bearing contact areas and pistons
d. Reduces wear and corrosion
e. Cleans engine parts
f. Forms seal between pistons, piston rings, and cylinder walls

Objective 19

a. 4
b. 1
c. 7
d. 8
e. 3
f. 5
g. 6
h. 2

Objective 20

Any four of the following:

a. Keeps a thin film on moving parts
b. Flows easily at low temperatures
c. Resists breakdown at high temperatures
d. Resists breakdown after long use
e. Resists corrosion and rusting
f. Resists foaming
g. Prevents carbon buildup
h. Prevents sludge formation
i. Produces low amount of ash

Objective 21

a. Temperature
b. More
c. Higher
d. Viscometer
e. Lighter
f. Heavier
g. Multigrade

Answers to Written Test

Objective 22

a. Oil specifications or qualities
b. Protection
c. C

Objective 23

Discussion should include any three of the following (in student's own words):

a. For proper protection, oil must be drained and changed at recommended intervals.
b. Use brands which meet the engine manufacturer's specifications.
c. Select oils that have been performance tested.
d. Never mix oils with different viscosities or API classifications.
e. Use quality oil filters as recommended by the operator's handbook or service manual.
f. Keep oil containers covered, sealed, and protected to prevent contamination.
g. Dispose of oil according to state and federal laws.

Objective 24

a. Parts
b. Gears
c. Metal
d. Engine oils
e. Any two of the following:

  - Transmission oil
  - Heavy duty engine oil
  - Gear oil
  - Automatic transmission fluid

f. Grade or type
g. Leaks
h. Red
i. Any two of the following:

  - Dexron I, II, III
  - Type A-A
  - Type C-3
  - Type F
  - Type H

j. Neutral
k. One of the following:

  - Gear oil—SAE 75-140 and API GL 1-6
  - Engine oil
  - Other gear lubricants

Answers to Written Test

Objective 25

a. T
b. T
c. F
d. T
e. F

Objective 26

b, c, e

Objective 27

a. Partial flow filter
b. Auxiliary flow filter

Objective 28

a. Eliminate
b. Manifold
c. Reservoir
d. More

Objective 29

a. Any one of the following:

- Liquid lubricant
- Soap base
- Additives for rust and corrosion resistance, adhesion, and withstanding extreme pressure

b. Any one of the following:

- Stable
- Pumpable
- Water resistant
- Heat resistant

Objective 30

Discussion should include any two of the following (in student's own words):

a. Although on-board lubrication systems minimize chassis and suspension service, some components such as drive shaft U-joints, axles, and wheel bearings still need to be manually lubricated at regular recommended intervals.
b. Use only lubricants that meet the equipment manufacturer's specifications for each individual lubrication point.
c. Always refer to the service manual for make, model, and type of equipment to be certain that all lubrication points are properly greased.
d. Check the level of lubricant in ACLS reservoirs at recommended intervals and fill only with the lubricant recommended by the equipment manufacturer.
e. Inspect the system lines to make sure they are working and correctly routed whenever you service an on-board system.

Answers to Written Test

Objective 31

a. Liquid acid solution (electrolyte)
b. Electrolyte level
c. Water
d. Sealed
e. Any one of the following: Corrosion, breaks, cracks, or other damage

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 16.

☐ 4. **View** Different types of filters used on diesel equipment and study their characteristics.

☐ 5. **View** Examples of fluids and lubricants commonly used on diesel equipment.

☐ 6. **Observe** Demonstration of procedures to be used in completing Job Sheets 1 and 2.

☐ 7. **Do** Job Sheet 1, "Test for Combustion Leakage into a Cooling System," and Job Sheet 2, "Test for Air in a Cooling System."

☐ 8. **Stop** Have instructor evaluate your performance on each procedure, and if the evaluations are satisfactory, continue to step 9. If either evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedures outlined in Job Sheets 1 and 2, and repeat steps 7 and 8.

☐ 9. **Observe** Demonstration of procedure to be used in completing Job Sheet 3.

☐ 10. **Do** Job Sheet 3, "Clean a Cooling System."

Learning Activities Sheet

☐ 11. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 3, and repeat steps 10 and 11.

☐ 12. **Study** Information Sheet, Objectives 17 through 23, and Student Supplement 1.

☐ 13. **Observe** Demonstration of procedure to be used in completing Job Sheet 4.

☐ 14. **Do** Job Sheet 4, "Change Oil and Oil Filter."

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 4, and repeat steps 14 and 15.

☐ 16. **Study** Information Sheet, Objectives 24 through 31.

☐ 17. **Check** With instructor for any additional assignments to be completed.

☐ 18. **Do** Additional assignments listed below.

____

____

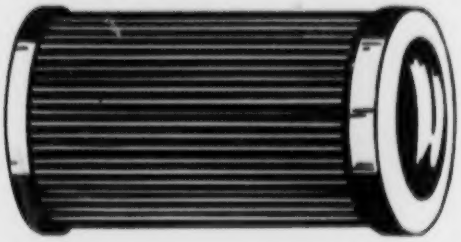
____

☐ 19. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

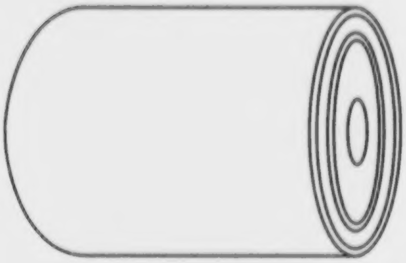
☐ 20. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

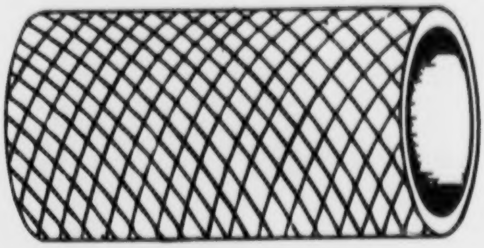
Common Types of Filters



Cartridge Filter

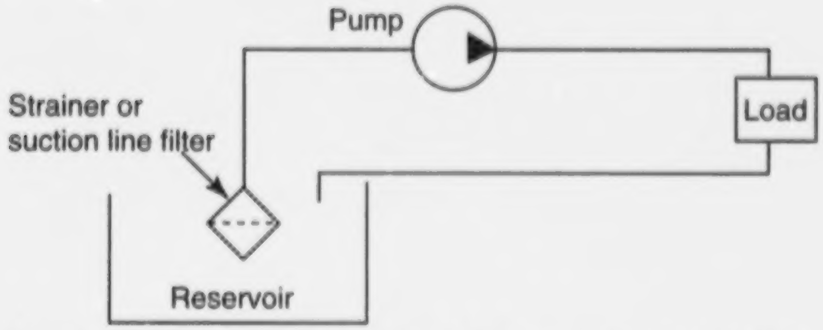


Spin-on Filter

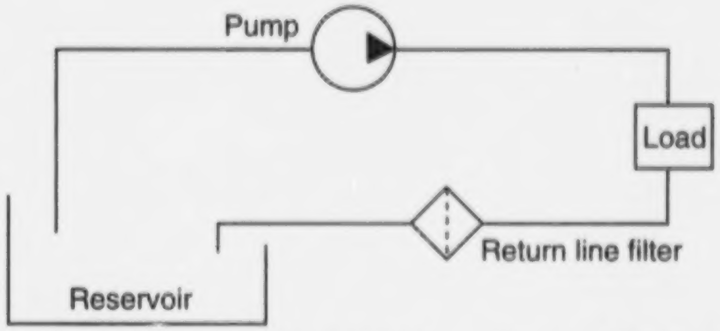


Strainer Filter

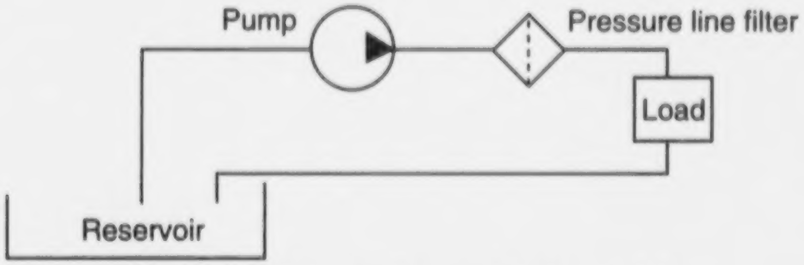
Locations of Filters in Hydraulic Systems


Pump
Load
Strainer or suction line filter
Reservoir

Strainer or Suction Line Filter—Pump Inlet

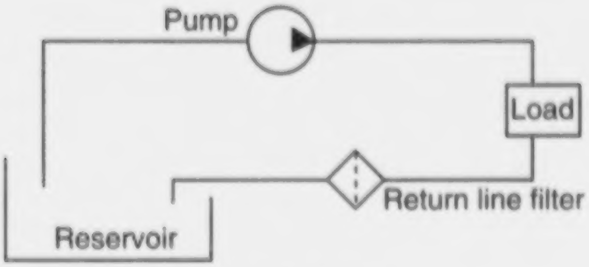

Pump
Load
Return line filter
Reservoir

Pressure Line Filter—Pump Outlet

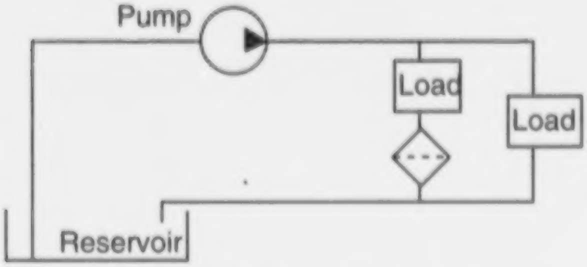

Pump
Pressure line filter
Load
Reservoir

Return Line Filter—Return Line Between Pump and Reservoir

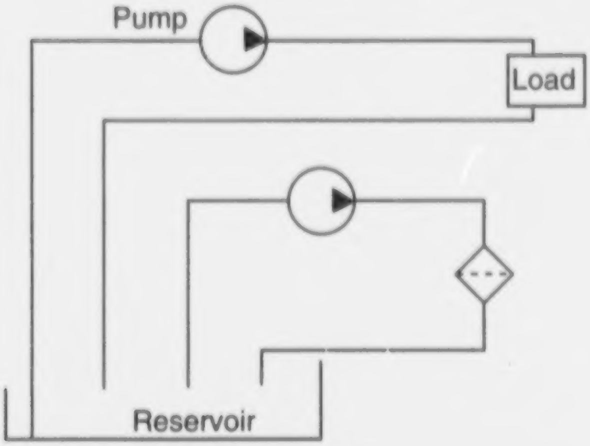
Types of Filter Circuits in Hydraulic Systems


Pump
Load
Return line filter
Reservoir

Full Flow Filter


Pump
Load
Load
Reservoir

Partial Flow Filter


Pump
Load
Reservoir

Auxiliary Flow Filter

Unit Contents

Teacher Page

Teacher Components

Suggested Activities 1C-3
Answers to Assignment Sheets 1C-9
Written Test 1C-11
Answers to Written Test 1C-23
Learning Activities Sheet 1C-27

Transparency Masters

1—Characteristics of Electricity 1C-31
2.—Ohm's Law 1C-33
3—Watt's Law 1C-35
4—Multimeters 1C-37
5—Basic Electrical Circuit Components 1C-39
6—Basic Electrical Circuits 1C-41
7—Electron Flow Through a Single Wire Circuit 1C-43
8—Circuit Protection Devices 1C-45
9—Battery Service Tools 1C-47

Student Page

Student Components

Objective Sheet 1C-3
Information Sheet 1C-5

Assignment Sheets

1—Solve Problems Using Ohm's Law 1C-31
2—Interpret Electrical Values From Multimeter Settings 1C-33
3—Interpret Wiring Diagrams 1C-39

Job Sheets

1—Measure Current, Voltage, and Resistance with a Multimeter 1C-43
2—Test and Replace Light Bulbs and Test Sockets 1C-49
3—Tin a Soldering Iron or Gun 1C-55
4—Solder-Splice Electrical Wiring 1C-57
5—Install Terminals and Connectors 1C-61
6—Test Charge a Conventional (Non-Sealed) Battery 1C-67
7—Test Charge a Sealed Battery 1C-71
8—Slow Charge a Battery 1C-73

Unit Contents

9—Perform a Battery Load Test 1C–79
10—Perform a High-Rate Battery Charge Test 1C–85
11—Emergency Jump-Start a Vehicle 1C–91

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Show the tools and instruments used to measure electrical characteristics. Also demonstrate how these should be used and how their readings will be used to diagnose electrical problems.
- Use mock-ups to demonstrate how a simple electrical circuit works. This could consist of a battery, copper wire, switch, and light or horn as the load device.
- Show examples of electrical circuit protection devices commonly used on diesel equipment. Show both good and bad (blown) devices.
- Show examples of wiring diagrams, and explain how to read them.
- Show the tools and materials used for soldering, and demonstrate their correct use.
- Discuss common battery service procedures, and show the correct tools and equipment that will be used for cleaning, testing, removing, and charging. Discuss the hazards associated with batteries, and explain appropriate safety procedures.
- Invite an electrical specialist from a local diesel equipment shop to talk about common repair work required on electrical systems, as well as the increasing use of electronics on diesel equipment.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Byrnes, Mike and Associates. *Bumper to Bumper*. Phoenix, AZ: Barron's Educational Series, Inc., 1993.
- Clark, Elton, et al. *Diesel Fundamentals*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.

- *Introduction to Automotive Service*. Stillwater, OK: Curriculum and Instructional Materials Center/Oklahoma Department of Vocational and Technical Education, 1989.
- Kaltwasser, Stan, et al. *Basic Wiring*, 2nd ed. Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1994.
- Schultz, Erich J. *Diesel Mechanics*. New York: Glencoe/McGraw-Hill, 1999.
- Turner, J. Howard. *Understanding Electricity and Electrical Terms*. Athens, GA: American Association for Vocational Instructional Materials.

Suggested Supplemental Resources

Print Media

- *Basic Electricity* (SEBV0534), instructional book that introduces electrical symbols, circuits, Ohm's law, magnetism, and generators

  The above is available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

- Self-paced training modules

  a. *Basic Electricity: Volts, Ohms, and Amps* (SDF-006)

  b. *Basic Electricity: Magnetism* (SDF-007)

  c. *Basic Electricity: Symbols and Diagrams* (SDF-008)

  d. *Basic Electricity: Terms* (SDF-009)

  The above are available from:

  Freightliner Corporation
  Technical Training Department
  5169 N. Lagoon Avenue
  Portland, OR 97217

- *Battery Service Manual.* Covers battery construction, theory of operation, troubleshooting, and service procedures. Available from:

  Battery Council International
  401 N. Michigan Avenue
  Chicago, IL 60611
  312-644-6610

Electronic Media

- *Mack Electrical Concepts Kit* (includes video, service manual and five guide books) (catalog number 8-099K). Available from your local Mack Truck service center or contact:

  Mack Trucks, Inc.
  2100 Mack Blvd.
  P.O. Box M
  Allentown, PA 18105-5000
  610-439-3011

- *Working with Ohm's Law* VHS cassette
- *Series Circuits and Ohm's Law* VHS cassette or CD-ROM
- *Parallel Circuits and Ohm's Law* VHS cassette

  The above are available from:

  Bergwall Productions Inc.
  540 Baltimore Pike
  P.O. Box 2400
  Chadds Ford, PA 19317-9904
  800-645-3565 or 610-388-0400

- *How to Test a Cat Battery* (SEVN1590), 11-minute video
- *Battery Maintenance* (SESV1512), 62 slides that cover battery principles, maintenance, charging, and testing

  The above are available from your local CAT dealer or write the following for more information:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

Suggested Activities

- *FOS Electronic/Electrical* set of 418 slides (FOS2007S-152) or 337 transparency masters (FOS2007M-152). Available from:

  Deere & Company
  Distribution Service Center
  P.O. Box 186
  Moline, IL 61266-1086

- *Charging and Testing*, 16-minute video available from:

  Delco-Remy/General Motors Corporation
  2401 Columbus Avenue
  Anderson, IN 46016
  317-646-2000

- *What is Electricity*, 9-minute video

- *Current Flow*, 9-minute video

- *Electrical Power*, 11-minute video

  The above are available from:

  International Film Bureau, Inc.
  332 S. Michigan Avenue
  Chicago, IL 60604-4382
  800-432-2241

Answers to Assignment Sheets

Assignment Sheet 1

Solve Problems Using Ohm's Law

1. 12 volts
2. 1 ohm
3. No
4. No
5. 5.8 amperes

Assignment Sheet 2

Interpret Electrical Values From Multimeter Settings

1. 46,900 ohms
2. 9 volts positive
3. 4.6 volts positive
4. 1.530 volts negative
5. 9.06 volts positive
6. 1.530 volts positive
7. 4,690 ohms
8. 2.45 amps
9. 1,000 ohms
10. 100 ohms
11. 100.6 ohms
12. 2.46 amps

Answers to Assignment Sheets

Assignment Sheet 3

Interpret Wiring Diagrams

1. No
2. Ground
3. Dome light
4. Yes
5. Three
6. Orange
7. Four
8. Parallel
9. 15
10. Ammeter

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Ampere
2. Analog volt-ohm-meter (VOM)
3. Circuit
4. Current
5. Conductor
6. Digital volt-ohm-meter (DVOM)
7. Electrode
8. Electrolyte
9. Fuse
10. Insulator
11. Load
12. Open (circuit)
13. Oscilloscope
14. Resistance
15. Semiconductor
16. Short circuit (short)
17. Voltage
18. Waveform
19. Wiring diagram (schematic)

_____ a. Portion of an electric circuit where electricity is converted to another form of energy

_____ b. Material that resists the flow of electricity

_____ c. Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source

_____ d. Quantity of current flowing through a conductor or circuit

_____ e. Electrical safety device with a wire or easily melted metal strip

_____ f. Meter that uses a needle pointer and scale to display volts, amps, or ohms

_____ g. Nonmetallic conductor (such as battery acid and water) that carries current between positive and negative points

_____ h. Accidental low resistance connection between two points that results in an alternate current path that either deflects current from the desired paths or will cause excessive current that can result in damage to circuit components

_____ i. Electronic meter that displays a voltage signal over a unit of time on a TV-like display screen or LCD screen

_____ j. Flow of electrons through a conductor

Written Test

____ k. Material that under certain operating conditions acts like a conductor; under other conditions it will act like an insulator

____ l. Conductor such as a battery terminal that connects electrolyte to a metallic conductor

____ m. Material through which electricity flows easily

____ n. Electrical pressure used to move electrons through a conductor

____ o. Electrical property of a conductor or device that opposes the flow of current

Objective 2

Distinguish between true and false statements regarding the electron theory of electricity by placing a "T" or "F" in the appropriate blanks.

____ a. Everything is made up of atoms.

____ b. Atoms are made up of protons, neutrons, and electrons.

____ c. Neutrons carry a negative (–) charge.

____ d. Electrons carry a positive (+) charge.

____ e. The middle of an atom is called the nucleus.

____ f. Electrons in the outer orbit are called radical electrons.

Objective 3

Match characteristics of electricity with their correct descriptions.

1. Current Intensity (I)
2. Electromotive Force (emf) (E)
3. Resistance (R)

____ a. The amount of energy in a current measured as the pressure that pushes electron flow

____ b. The number of electrons flowing past a given point in a second

____ c. The amount of a substance's opposition to electrical flow

Objective 4

Match the basic electrical units with their measurements.

1. Ampere (Amp)
2. Ohm (Ω)
3. Volt (V)
4. Watt

_____ a. Measures resistance (R)

_____ b. Measures electrical power (P)

_____ c. Measures the intensity (I) of an electrical current

_____ d. Measures electromotive force (E)

Objective 5

Express Ohm's law and Watt's law by stating the correct formula or by drawing the correct triangle expression

a. Ohm's law

b. Watt's law

Objective 6

Match the equipment used to measure electrical characteristics with their definitions. Definitions continue on the next page.

1. Ammeter
2. Analog volt-ohm-meter (VOM)
3. Digital volt-ohm-meter (DVOM)
4. Multimeter
5. Ohmmeter
6. Self-powered test light
7. Test light
8. Voltmeter

_____ a. Indicates the presence of current without measuring any of its characteristics

_____ b. Uses electronic circuitry to measure the selected electrical property and displays a numeric reading

_____ c. Measures resistance

_____ d. Measures electromotive force, current, and resistance; may be analog or digital

_____ e. Measures current intensity

_____ f. Uses current to move a needle that indicates the level of the selected electrical characteristics

_____ g. Measures electromotive force

Objective 7

Match the components of a basic electrical circuit with their purposes.

1. Conductor
2. Energy source
3. Load
4. Switch

_____ a. Opens or closes the circuit

_____ b. Produces the energy that causes electrons to flow

_____ c. Provides a path for the electricity to flow from the power source and through the circuit; usually copper wire in diesel equipment

_____ d. Converts electricity into another form of energy

Objective 8

Distinguish between types of electrical current flow by placing the following letter next to the correct descriptions:

- AC = next to alternating current flow
- DC = next to direct current flow

_____ a. The energy source is generally a commercial power source.

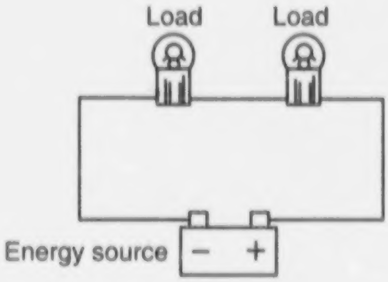
_____ b. Electricity flows in one direction only.

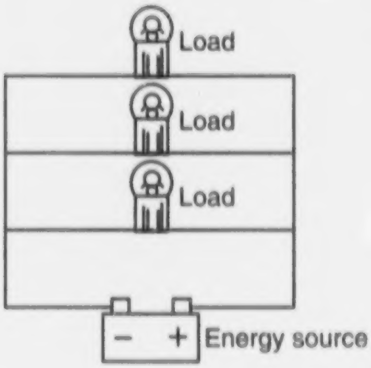
_____ c. The energy source is generally a battery.

_____ d. Electricity flows in one direction and then reverses direction on a regular basis.

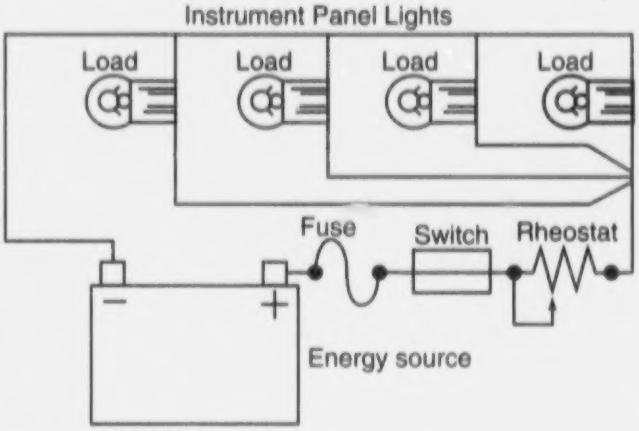
Objective 9

Identify to following types of basic electrical circuits. Write your answers in the blanks provided.


Load
Load
Energy source
−
+


Load
Load
Load
−
+
Energy source

a. ______________________ b. ______________________


Instrument Panel Lights
Load
Load
Load
Load
Fuse
Switch
Rheostat
−
+
Energy source

c. ______________________

Objective 10

Describe electron flow through a single wire circuit for a negative ground and a positive ground.

a. Negative ground

____

____

____

b. Positive ground

____

____

____

Objective 11

Match the circuit protection devices with their definitions.

1. Circuit breaker
2. Fuses
3. Fusible links

_____ a. Are specially insulated wires that melt when excessive current flows through them, permanently opening the circuit until replaced or repaired

____ b. Contains a bimetal strip that bends away from contact points when excessive current flows through the circuit. When the bimetal strip cools, it straightens, and the points make contact again.

____ c. Are devices that contain a soft metal conductor that melts when excessive current flows through it, permanently opening the circuit until replaced

Objective 12

Distinguish among types of electrical circuit problems by placing the following letter next to the correct descriptions:

- H = next to high resistance circuit problems
- O = next to open circuit problems
- S = next to short circuit problems

_____ a. Electricity flows from the circuit into another conductor, usually as a result of a conductor penetrating wire insulation or an exposed switch or load surface

____ b. Condition in which a break in the circuit prevents current flow

____ c. Condition in which circuit conductivity is reduced to the point that current flow is not sufficient to operate loads

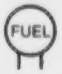
____ d. Condition in which current flows out of the intended circuit

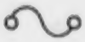
____ e. A switch in the off position

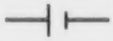
____ f. Affected by the diameter ("gauge") of the conductor

Objective 13

Identify the following schematic symbols used on wiring diagrams. Write your answers in the blanks provided.



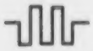


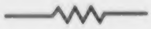


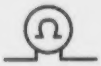
a. ______________

b. ______________

c. ______________



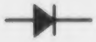


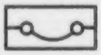


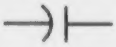
d. ______________

e. ______________

f. ______________



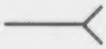


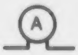


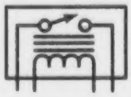
g. ______________

h. ______________

i. ______________



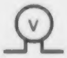


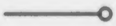


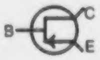
j. ______________

k. ______________

l. ______________



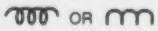




m. ______________

n. ______________

o. ______________



p. ______________

Written Test

Objective 14

Complete statements concerning how to read wiring diagrams by filling in the blanks with the correct answers.

a. Grounds are usually labeled with the letter ____________________ and a ____________________.

b. When tracing power flow through a wiring diagram, one would normally start at the ____________________ and ____________________.

c. In many diagrams there is no return wire as the ____________________ or frame provides that path.

d. The top of the wiring diagram is the ____________________ of the circuit.

e. The bottom of the wiring diagram is the ____________________ path back to the battery.

Objective 15

Arrange in order the following steps for soldering by placing the correct sequence numbers (1-7) in the appropriate blanks.

_____ a. Put on safety glasses and then prepare soldering iron or soldering gun by cleaning and tinning the tip with a thin coat of rosin-core solder.

_____ b. Reinsulate the connection using electrical tape or heat-shrink insulation and a heat gun.

_____ c. Strip wire (remove its insulation) using an electrician's stripper-crimper. Use the proper hole for the gauge of wire you are stripping to prevent nicks and cuts.

_____ d. Solder exposed pieces of spliced wiring using soldering iron or gun and rosin-core solder.

_____ e. Twist or splice the exposed wiring securely, but gently.

_____ f. Allow solder to cool and then test connection to make sure it is secure.

_____ g. Clean the exposed wiring using rosin-type cleaning-flux solution (not acid flux!) to ensure a good electrical connection.

Objective 16

Complete statements concerning guidelines for soldering by filling in the blanks with the correct answers.

a. When soldering, enough heat must be generated so that the solder ____________________ and does not become pasty or mushy.

b. Move the solder along the wiring to allow the solder to cover the ____________________.

c. Use only enough solder to flow between the ____________________ to form a good bond.

d. A poorly soldered connection—a connection soldered with heat insufficient to properly heat the wire, called a ____________________—will have a dull, rough appearance.

e. Soldered connections must meet two requirements:

- Good physical connection
- ____________________

Objective 17

Complete statements concerning electrical terminals and connectors by circling the correct answers.

a. A terminal is a small (**conductive, nonconductive**) device that is attached to the end of a wire so that the wire can be easily connected and disconnected to other wires or electrical-circuit components.

b. In terminal pairs, one terminal is called a (**female, positive**) terminal and the other is called a (**male, negative**) terminal.

c. A connector is a (**conductive, nonconductive**) device that holds two or more terminals in position.

d. Terminals and connectors to be used in locations exposed to moisture or in circuits carrying large amounts of current must be (**soldered, welded**) in place.

e. For most other applications, terminals and connectors can merely be crimped to wires with the crimping area of a (**wire stripper-crimper, electrician's wrench**).

f. Crimped connections are called (**crimps, solderless**).

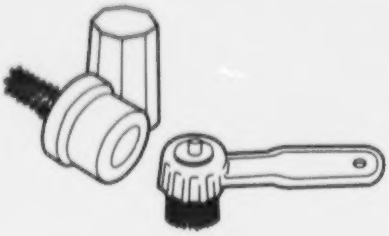
g. Solderless terminals and connectors are (**different sizes, color-coded**) to ensure that you select the proper terminal or connector for the conductor to which it will be attached.

h. Solderless terminals and connectors with (**yellow, red**) ends are to be used with 18-gauge and smaller conductors.

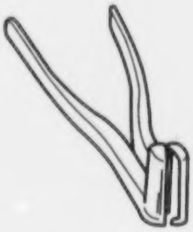
Written Test

Objective 18

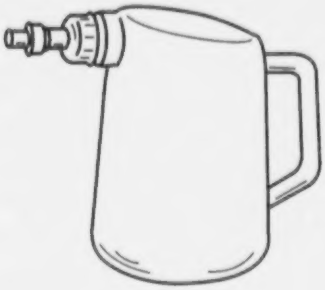
Identify the following battery service tools. Write your answers in the blanks provided.



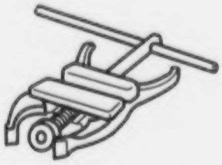
a. ______________________



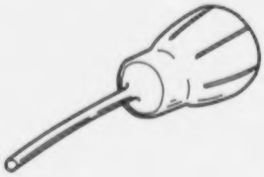
b. ______________________



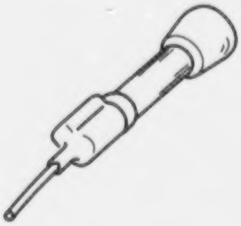
c. ______________________



d. ______________________



e. ______________________



f. ______________________

Objective 19

Complete statements concerning guidelines for servicing batteries by circling the correct answers.

a. The charge on conventional batteries can be determined by checking the (**terminal posts, electrolyte weight**).

b. A change in temperature will change the (**number of electrons in, specific gravity of**) electrolyte, which in turn affects the accuracy of the reading you will get from the hydrometer.

c. Temperature-compensating hydrometers automatically adjust readings for electrolyte temperatures above or below (**80°F, 100°F**).

d. A battery charger is commonly used to increase the percentage of charge on a (**weak, strong**) battery.

e. A conventional battery is considered fully charged when all cells are gassing freely, specific gravity tests between 1.260 and 1.280, and no change occurs in specific gravity readings when tested over a (**three-, twenty-four**) hour period after the charging procedure.

f. A sealed battery is considered fully charged when the (**red, green**) dot is visible in the hydrometer's sight glass.

g. A/An (**oscilloscope, volt-amp tester**) is commonly used to load test a battery.

Objective 20

Distinguish between correct and incorrect safety procedures to follow when working on batteries by placing the following letter next to the correct descriptions:

- C = next to correct safety procedures
- I = next to incorrect safety procedures

_____ a. Always charge, test, or jump-start a sealed battery when the hydrometer appears clear or light yellow.

____ b. Never lay any conductor across battery terminals.

____ c. Always break live circuits at the battery.

____ d. When connecting jumper cables to a battery, always connect the ground to vehicle frame or engine toward the battery.

____ e. Always keep a mixture of baking soda and water nearby when working with batteries.

____ f. When disconnecting battery cables, always disconnect the insulated-terminal (positive) cable clamp first, and when reconnecting cables, always reconnect the grounded-terminal (negative) clamp first.

____ g. When using a battery charger, make connections before plugging the charger into the shop's wall outlet.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a.	11	f.	2	k.	15
b.	10	g.	8	l.	7
c.	3	h.	16	m.	5
d.	1	i.	13	n.	17
e.	9	j.	4	o.	14

Objective 2

a.	T
b.	T
c.	F
d.	F
e.	T
f.	F

Objective 3

a.	2
b.	1
c.	3

Objective 4

a.	2
b.	4
c.	1
d.	3

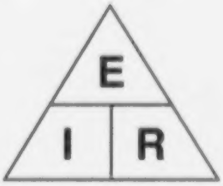
Objective 5

Any of the following are correct:

a. Ohm's Law

- E=I x R
- I=E/R
- R=E/I

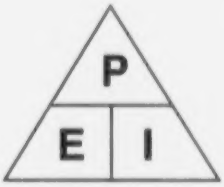
or



b. Watt's Law

- P=E x I
- I=P/E
- E=P/I

or



Objective 6

a.	6 or 7	e.	1
b.	3	f.	2
c.	5	g.	8
d.	4		

Answers to Written Test

Objective 7

a. 4
b. 2
c. 1
d. 3

Objective 8

a. AC
b. DC
c. DC
d. AC

Objective 9

a. Series circuit
b. Parallel circuit
c. Series-parallel circuit

Objective 10

Descriptions should include the following (in the student's own words):

a. **Negative ground** (most common)

- The negative terminal of the battery is connected to the equipment frame or chassis (ground).
- One side of the load is also connected to the frame or chassis (ground) for the return path.
- The positive terminal of the battery is connected to the load with insulated wire and a control device, completing the path for current flow.

b. **Positive ground**

- The positive terminal of the battery is connected to the equipment frame or chassis (ground).
- One side of the load is also connected to the frame or chassis for the return path.
- The negative terminal of the battery is connected to the load with insulated wires and a control device, completing the path for current flow.

Objective 11

a. 3
b. 1
c. 2

Answers to Written Test

Objective 12

a. S
b. 0
c. H
d. S
e. O
f. H

Objective 13

a. Gauge-fuel
b. Fuse
c. Battery—one cell
d. Bimetal strip
e. Resistor
f. Ohmmeter
g. Diode
h. Circuit breaker
i. Capacitor
j. Connector—female contact
k. Ammeter
l. Relay
m. Voltmeter
n. Termination
o. PNP transistor
p. Winding—inductor

Objective 14

a. "G" and number
b. Voltage and current source
c. Chassis
d. Positive
e. Ground

Objective 15

a. 4
b. 7
c. 1
d. 5
e. 3
f. 6
g. 2

Objective 16

a. Flows freely as a liquid
b. Length of the splice
c. Wiring strands
d. Cold joint
e. Good electrical connection

Answers to Written Test

Objective 17

a. Conductive
b. Female, male
c. Nonconductive
d. Soldered
e. Wire stripper-crimper
f. Solderless
g. Color-coded
h. Red

Objective 18

a. Battery post cleaner
b. Terminal spreader plier
c. Automatic battery filler
d. Battery terminal clamp puller
e. Battery syringe
f. Battery hydrometer

Objective 19

a. Electrolyte weight
b. Specific gravity
c. 80°F
d. Weak
e. Three-
f. Green
g. Volt-amp tester

Objective 20

a. I
b. C
c. I
d. I
e. C
f. I
g. C

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 5.

☐ 4. **Do** Assignment Sheet 1, "Solve Problems Using Ohm's Law."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat steps 3 through 5.

☐ 6. **Study** Information Sheet, Objectives 6 through 12.

☐ 7. **Go to** Shop area and view tools and instruments used to measure electrical characteristics, and view good and bad (blown) circuit protection devices. Study the various parts of the meters and their functions.

☐ 8. **Do** Assignment Sheet 2, "Interpret Electrical Values From Multimeter Settings."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, repeat steps 6, 8, and 9.

☐ 10. **Observe** Demonstration of procedure to be used in completing Job Sheet 1.

☐ 11. **Do** Job Sheet 1, "Measure Current, Voltage, and Resistance With a Multimeter."

Learning Activities Sheet

☐ 12. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 1 and repeat steps 11 and 12.

☐ 13. **Study** Information Sheet, Objectives 13 and 14.

☐ 14. **Ask** Your instructor to show you examples of wiring diagrams and how to read a wiring diagram.

☐ 15. **Do** Assignment Sheet 3, "Interpret Wiring Diagrams."

☐ 16. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat steps 13, 15, and 16.

☐ 17. **Observe** Demonstration of procedure to be used in completing Job Sheet 2.

☐ 18. **Do** Job Sheet 2, "Test and Replace Light Bulbs and Test Sockets."

☐ 19. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 2 and repeat steps 18 and 19.

☐ 20. **Study** Information Sheet, Objectives 15 through 17.

☐ 21. **Go to** Shop area and view tools and instruments used for soldering.

☐ 22. **Observe** Demonstration of procedure to be used in completing Job Sheets 3 and 4.

☐ 23. **Do** Job Sheet 3, "Tin a Soldering Iron or Gun," and Job Sheet 4, "Solder-Splice Electrical Wiring."

☐ 24. **Stop** Have instructor evaluate your performance on each procedure and if the evaluations are satisfactory, continue to step 25. If either evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedures outlined in Job Sheets 3 and 4 and repeat steps 23 and 24.

☐ 25. **Observe** Demonstration of procedure to be used in completing Job Sheet 5.

☐ 26. **Do** Job Sheet 5, "Install Terminals and Connectors."

☐ 27. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 28. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 5 and repeat steps 26 and 27.

☐ 28. **Study** Information Sheet, Objectives 18 through 20.

☐ 29. **Go to** Shop area and view tools and instruments that will be used for cleaning, testing, removing, and charging a battery.

☐ 30. **Observe** Demonstration of procedures to be used in completing Job Sheets 6 and 7. Ask instructor about hazards associated with batteries, and have him/her explain appropriate safety procedures.

☐ 31. **Do** Job Sheet 6, "Test Charge a Conventional (Non-Sealed) Battery," and Job Sheet 7, "Test Charge a Sealed Battery."

☐ 32. **Stop** Have instructor evaluate your performance on each procedure and if the evaluations are satisfactory, continue to step 33. If either evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedures outlined in Job Sheets 6 and 7 and repeat steps 31 and 32.

☐ 33. **Observe** Demonstration of procedure to be used in completing Job Sheet 8.

☐ 34. **Do** Job Sheet 8, "Slow Charge a Battery."

☐ 35. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 36. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 8 and repeat steps 34 and 35.

☐ 36. **Check** With instructor for any additional assignments to be completed.

☐ 37. **Do** Additional assignments listed below.

____

____

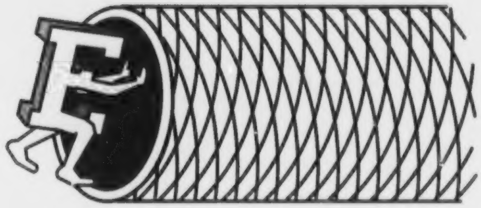
____

☐ 38. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 39. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

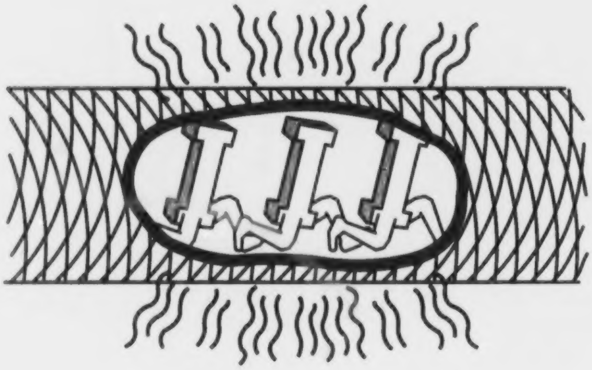
***Permission to duplicate this form is granted.**

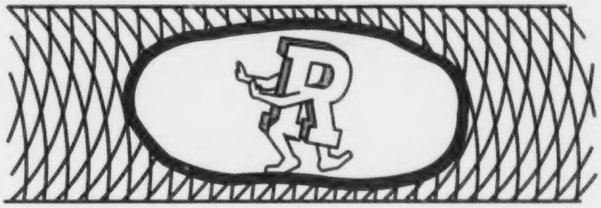
Characteristics of Electricity



Electromotive Force (E)
Pressure that pushes
electron flow; Measured in volts.

Intensity (I) or Current
Number of electrons flowing;
Measured in amps.

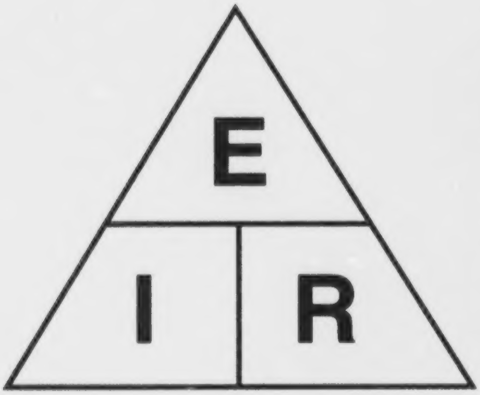




Resistance (R)
Opposition to electron flow;
Measured in ohms.

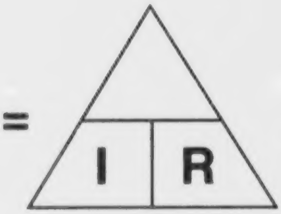
TM 1

Ohm's Law



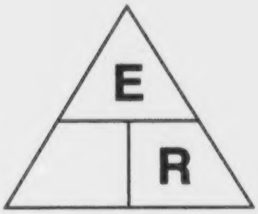
E = Volts
I = Amps
R = Ohms

E =



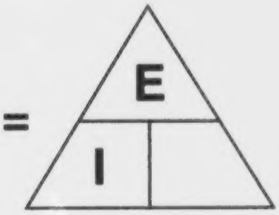
E = I x R
Volts = Amps x Ohms

I =



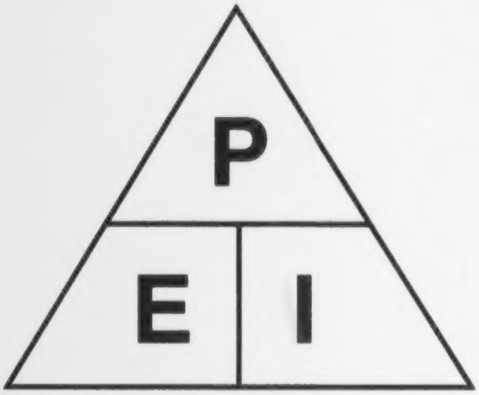
I = E/R
Amps = Volts ÷ Ohms

R =



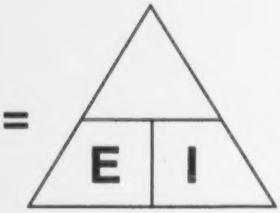
R = E/I
Ohms = Volts ÷ Amps

Watt's Law



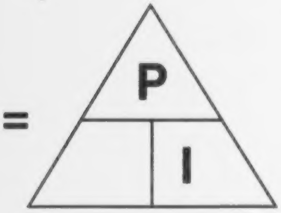
P = Watts
E = Volts
I = Amps

P =



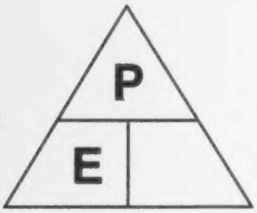
P = E x I
Watts = Volts x Amps

E =



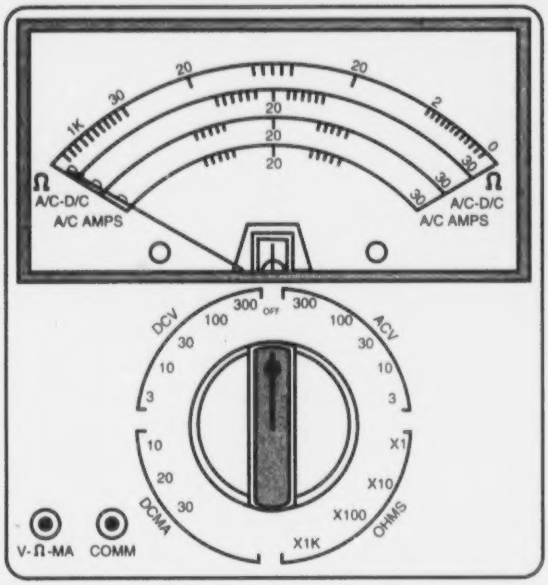
E = P ÷ I or $\frac{P}{I}$
Volts = Watts ÷ Amps

I =



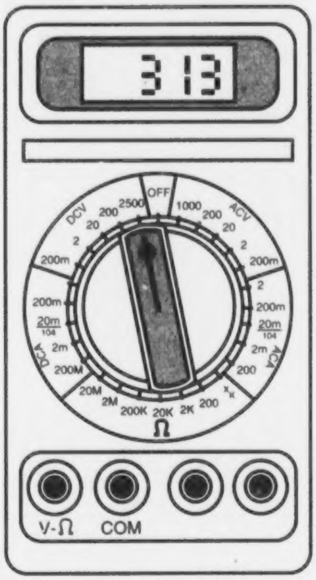
I = P ÷ E or $\frac{P}{E}$
Amps = Watts ÷ Volts

Multimeters



Ω
A/C-D/C
A/C AMPS
1K
30
20
20
20
20
20
2
0
30
30
30
Ω
A/C-D/C
A/C AMPS
DCV
300
OFF
300
ACV
100
30
10
3
100
30
10
3
10
20
30
DCMA
X1
X10
X100
X1K
OHMS
V-Ω-MA
COMM

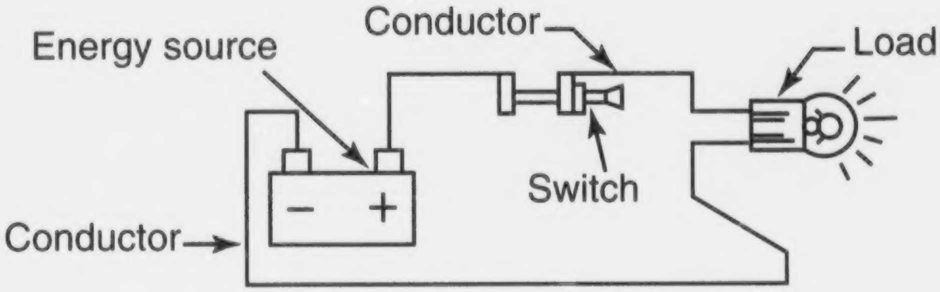
Analog Multimeter (VOM)



313
OFF
DCV
2500
200
20
2
200m
1000
200
20
2
200m
ACV
2
200m
20m
10⁴
2m
200
ACA
200m
20m
10⁴
2m
200M
DCA
20M
2M
200K
20K
2K
200
Ω
V-Ω
COM

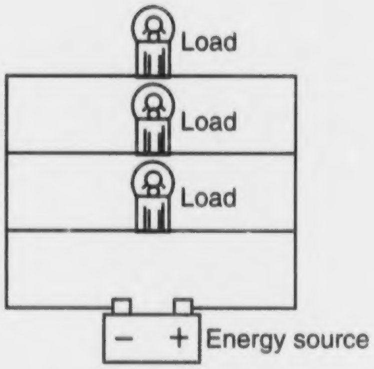
Digital Multimeter (DVOM)

Basic Electrical Circuit Components

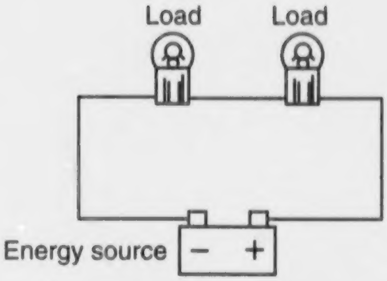

Conductor
Energy source
Load
Switch
Conductor

348

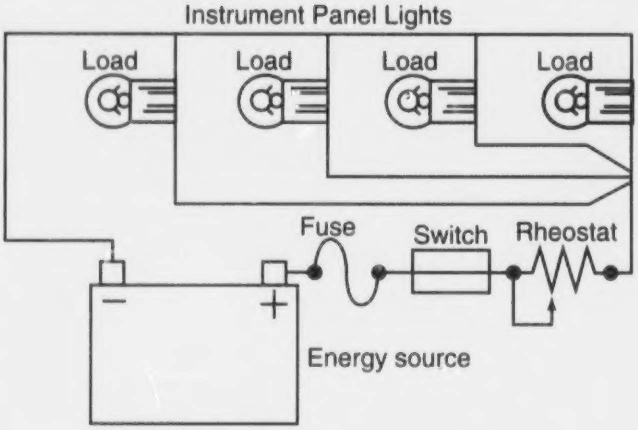
Basic Electrical Circuits


Load
Load
Load
−
+
Energy source

Parallel circuit

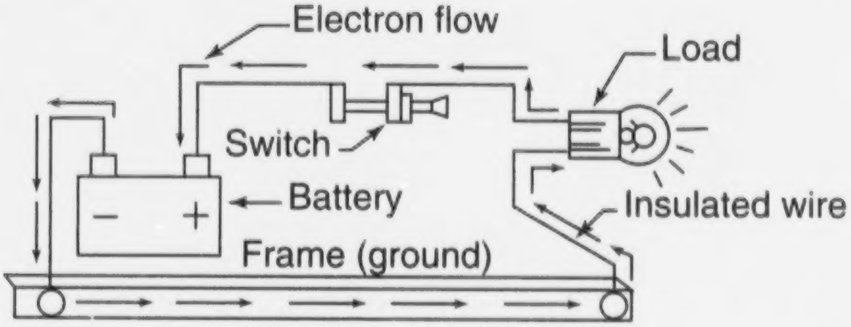

Load
Load
Energy source
−
+

Series circuit

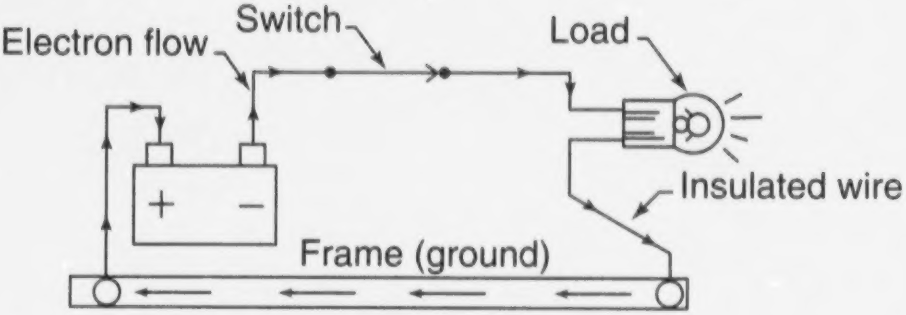

Instrument Panel Lights
Load
Load
Load
Load
Fuse
Switch
Rheostat
−
+
Energy source

Series-parallel circuit

Electron Flow Through a Single Wire Circuit

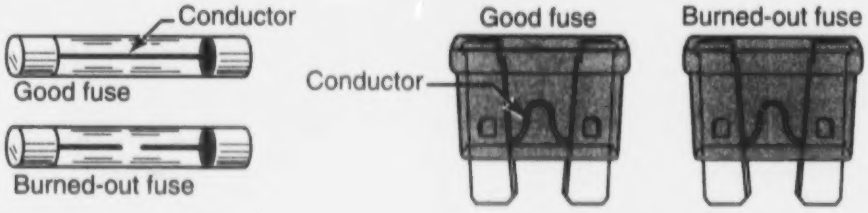

Electron flow
Load
Switch
Battery
−
+
Insulated wire
Frame (ground)

Negative ground


Switch
Electron flow
Load
Insulated wire
+
−
Frame (ground)

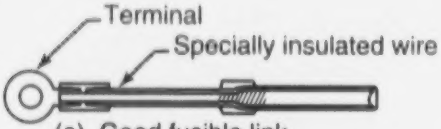
Positive ground

Circuit Protection Devices

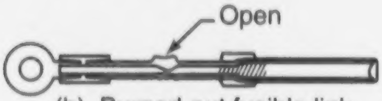

Conductor
Good fuse
Burned-out fuse
Good fuse
Burned-out fuse
Conductor

(a) Tube-type glass fuse **(b) Miniaturized translucent fuse**

Fuses

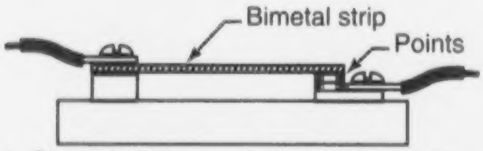

Terminal
Specially insulated wire

(a) Good fusible link

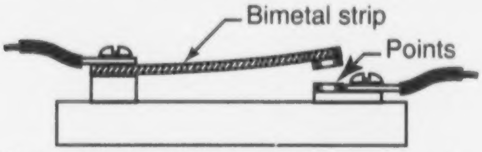


(b) Burned-out fusible link

Fusible links


Bimetal strip
Points

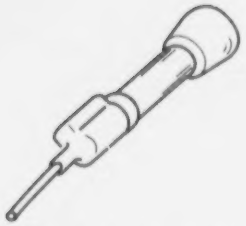
(a) Circuit breaker carries normal current;
bimetal strip contacts points. Circuit is closed.

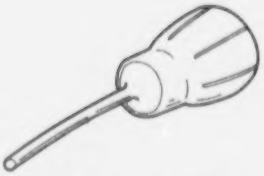

Bimetal strip
Points

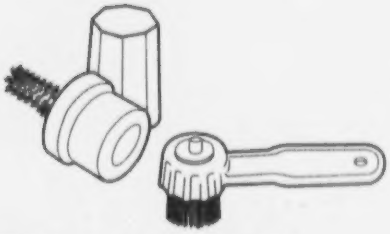
(b) Circuit breaker carries excessive current;
bimetal strip bends away from points. Circuit is open.

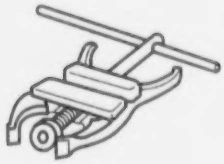
Circuit breakers

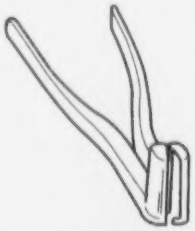
Battery Service Tools

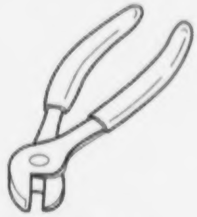

Battery hydrometer

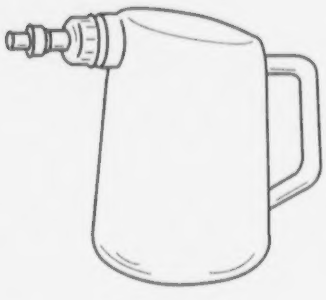

Battery syringe

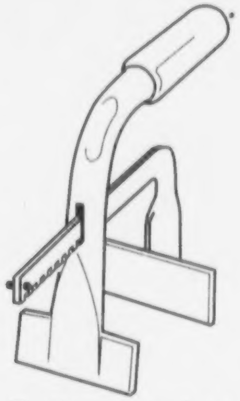

Battery post cleaner


Battery terminal
clamp puller


Terminal
spreader plier


Angle nose
(battery bolt) plier


Automatic
battery filler


Battery carrier

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 2C-3

Written Test 2C-9

Answers to Written Test 2C-15

Learning Activities Sheet 2C-19

Transparency Masters

1—Components of a Hydraulic System 2C-21
2—Simple Hydraulic System Block Diagram 2C-23
3—Basic Principles of Hydraulics 2C-25
4—Application of Hydraulic Principles 2C-27
5—Calculating Pressure 2C-29

Student Components

Student Page

Objective Sheet 2C-3

Information Sheet 2C-5

Assignment Sheet

1—Draw a Block Diagram of a Simple Hydraulic System 2C-15

Job Sheets

1—Perform General Maintenance Procedures
on a Hydraulic System 2C-17
2—Change Hydraulic Fluid and Filter 2C-19

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of this activity.

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students make a list of equipment in the shop that use hydraulics. Then take them on a tour of the shop and point out other equipment or other places (systems) on equipment that they didn't realize used hydraulics.
- Show students (or have students show you) the components of a basic hydraulic system using actual equipment in the shop.
- Demonstrate the basic hydraulic principles (Objective 6) and the operation of a hydraulic system using a hydraulic jack or other simple hydraulic device.
- Show the parts of a reservoir and demonstrate how and what to check.
- Invite a local equipment manufacturer representative or service manager to discuss with the class the most common service procedures and preventive maintenance required on hydraulic systems. Help students prepare questions in advance so the speaker will understand what to cover. Have the speaker allow time for more questions from the floor.
- Discuss safety hazards associated with hydraulic systems, and explain appropriate safety practices.
- Demonstrate how to perform general maintenance on a hydraulic system.
- Show examples of hydraulic fluids and filters and indicate which ones students will be using in Job Sheet 2.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheet. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Clark, Elton, et al. *Diesel Fundamentals.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- Dagel, John F. *Diesel Engine and Fuel System Repair*, 3rd ed. Upper Saddle River, NJ: Prentice Hall, 1994.
- Decker, Robert L. Revised by Klane Kirby. *Hydraulics*, 2nd ed. Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1986.
- Evett, Jack B. *Fundamentals of Fluid Mechanics and Hydraulics.* New York: McGraw-Hill Book Company, 1987.
- *Fundamentals of Service: Hydraulics.* Moline, IL: Deere and Company, 1992.
- Schultz, Erich J. *Diesel Mechanics.* New York: Glencoe/McGraw-Hill, 1999.

Suggested Supplemental Resources

Print Media

- *Principles of Hydraulics* (3387069) book, set of slides, or audio tape. Available from your local Cummins Engine Company dealer/distributor or call:

  Cummins Engine Company Customer Relations
  800-345-5654 or 502-453-8549 or for more information call 800-DIESELS

- Understanding Basic Hydraulics (H1-4DSD) study guide that discusses hydraulic theory and components.

  The above is available from:

  Dana Corporation
  Publication Services
  P.O. Box 453
  Toledo, OH 43692-0453
  419-535-4285

- *Hydraulics* (SEBV0529). Instructional book that teaches basic facts about hydraulic systems. (1989)
- *Hydraulic Pumps Schematic (Symbols vs. Sectional)* for E110B and E120B Hydraulic Excavators (SEWV1353), wall chart. (1991)

The items on the previous page are available from your local CAT dealer or write the following for more information:

Caterpillar Service Training
600 W. Washington St., Bldg. JJ
East Peoria, IL 61630

Electronic Media

- *Principles and Fluids.* 18-minute VHS cassette or CD-ROM. Gives overview of fluid power system, definitions, math refresher, and Pascal's Law.

- *Actuators.* 18-minute VHS cassette or CD-ROM. Examines cylinder and motors and shows calculations for cylinder velocity, force, rpm, torque, and power.

- *Pumps and Power Units.* 16-minute VHS cassette or CD-ROM. Identifies main components of power units and main types of pumps, as well as filters and displacement.

  The above are available from:

  Bergwall Productions Inc.
  540 Baltimore Pike
  P.O. Box 2400
  Chadds Ford, PA 19317-9904
  800-645-3565 or 610-388-0400

- Doctor of Fluid Power Computer-Aided Self-Training (CAST) instructional software for Apple II family. Includes the following programs:

  — *Basic Hydraulics* (DFP-101)
  — *Vane Pumps/Piston Pumps* (DFP-102)
  — *Hydraulic Symbols I* (DFP-103)
  — *Hydraulic Symbols II* (DFP-104)
  — *Valves* (DFP-105)

  The above are available from:

  Dana Corporation
  Publication Services
  P.O. Box 453
  Toledo, OH 43692-0453
  419-535-4285

Suggested Activities

- *FOS Hydraulics* set of 240 slides (FOS1005S-152) and 185 transparency masters (FOS1005M-152).

  Deere & Company
  Distribution Service Center
  P.O. Box 186
  Moline, IL 61266-1086

Written Test

Name ______________________________

Date ______________________ Score__________

Objective 1

Match the terms with their definitions

1. Actuator	6. Liquid
2. Cavitation	7. Pressure
3. Fluid	8. Pump
4. Hydraulics	9. Reservoir
5. Line	10. Valve

_____ a. Container for keeping a supply of working fluid in a hydraulic system

____ b. Tube, pipe, or hose for conducting a fluid

____ c. Formation of air bubbles in the inlet of a pump because the inlet does not completely fill with fluid

____ d. Substance (liquid or gas) that has no shape of its own and tends to flow

____ e. Device that forces the flow of hydraulic fluid; converts mechanical energy into hydraulic energy

____ f. Device that controls either pressure of fluid, direction of fluid flow, or rate of flow

____ g. Device that converts hydraulic energy into mechanical energy

____ h. Study of liquids in motion and at rest

Objective 2

Name four systems that use hydraulics in diesel technology.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Written Test

Objective 3

Explain two advantages and two disadvantages of hydraulic systems.

a. Advantages

- ______________________________
- ______________________________

b. Disadvantages

- ______________________________
- ______________________________

Objective 4

Match the terms with their definitions.

1. Actuators
2. Cooler
3. Filter
4. Lines
5. Pump
6. Reservoir (or tank)
7. Valves

_____ a. Lowers or maintains low temperature of hydraulic fluid; optional component

____ b. Cleans the fluid

____ c. Perform desired outcome—movement; convert hydraulic energy (pressure) into mechanical energy (motion); may be cylinders or motors

____ d. Stores the hydraulic fluid; also helps to cool and filter the system

____ e. Forces fluid under pressure to and through system

____ f. Control the pressure, direction, or rate of fluid flow; several types including bypass, relief, control, and check

____ g. Carry the fluid

Objective 5

Arrange in order the following steps for the basic operation of a hydraulic system by placing the correct sequence numbers (1-5) in the appropriate blanks.

_____ a. Actuator uses hydraulic pressure to cause movement and to perform work.

____ b. Fluid is returned to reservoir.

____ c. Pump forces fluid through the lines to the chambers of a control valve.

____ d. Pump draws the fluid from the reservoir.

____ e. Control valve directs fluid to the actuator.

Objective 6

Complete statements concerning basic hydraulic principles by circling the correct answers.

a. Liquid (**can, cannot**) be compressed.

b. Liquid (**can, cannot**) be used to transmit force.

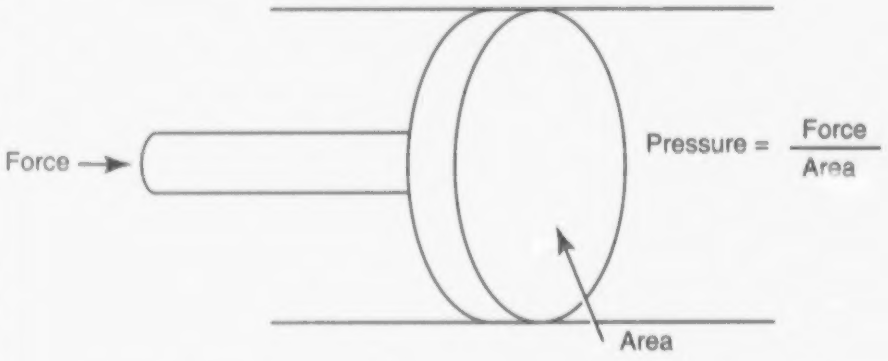
c. Liquid (**can, cannot**) be used to multiply force.

d. Pascal's Law states that pressure set up in a confined liquid acts (**equally, unequally**) in all directions.

e. If the input and output pistons have unequal areas and equal pressures, the input and output forces will be (**equal, unequal**).

Objective 7

Calculate pressure for the following problems by using the given formula.



a. If 10 pounds of force is applied to a surface with an area of 2 square inches, how much pressure is produced? ______________________

b. A piston with an area surface of 5 square inches is to be moved with a force of 30 pounds. How much pressure is produced? ______________

Written Test

Objective 8

Select functions of hydraulic fluid by placing an "X" in the blanks next to the true statements.

_____ a. Heating

____ b. Sealing

____ c. Power transmission

____ d. Creating friction

Objective 9

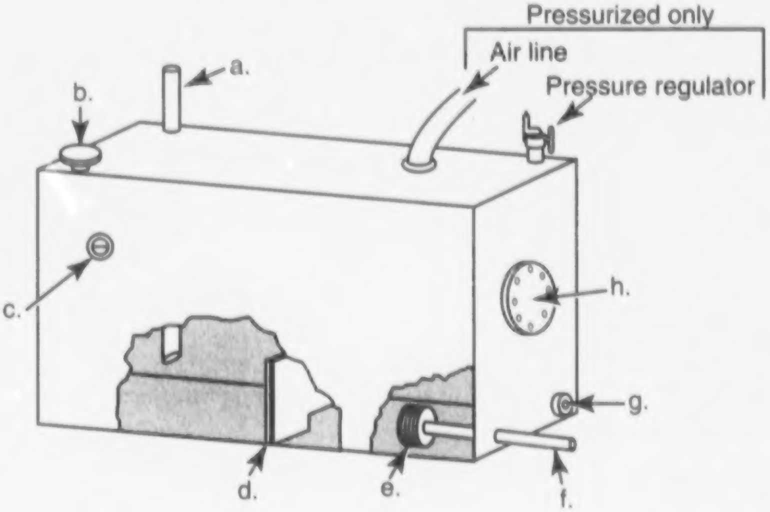
List two types of reservoirs.

a. ____

b. ____

Objective 10

Identify parts of a reservoir. Write your answers in the blanks provided.


Pressurized only
Air line
Pressure regulator
a.
b.
c.
d.
e.
f.
g.
h.

a. ____________________ b. ____________________

c. ____________________ d. ____________________

e. ____________________ f. ____________________

g. ____________________ h. ____________________

Objective 11

List two causes of damage to hydraulic systems.

a. ____

b. ____

Objective 12

Select common problems in hydraulic systems by placing an "X" in the appropriate blanks.

_____ a. Clogged or dirty oil filters

_____ b. Tight inlet lines

_____ c. Oil in the reservoir

_____ d. Incorrect oil in the system

Objective 13

Name two reasons for performing preventive maintenance on hydraulic systems.

a. ______________________________

b. ______________________________

Objective 14

List four of the six steps for general maintenance of a hydraulic system.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Objective 15

List two steps in keeping hydraulic systems clean.

a. ______________________________

b. ______________________________

Objective 16

Discuss at least three safety hazards and three safety practices when working with hydraulic systems.

a. Safety hazards:

- ______________________________
- ______________________________
- ______________________________

b. Safety practices:

- ______________________________
- ______________________________
- ______________________________

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 9
b. 5
c. 2
d. 3
e. 8
f. 10
g. 1
h. 4

Objective 2

Any four of the following:

a. Lifting systems and equipment
b. Auxiliary controls and actuators
c. Brakes
d. Hitch controls
e. Power steering
f. Retarders or engine brakes

Objective 3

a. Advantages—Any two of the following:

- Flexibility—Allows flexible transfer of large forces
- Multiplication of force—Small forces can be used to control large forces
- Simplicity—Has fewer moving parts and points of wear than a mechanical system; can lubricate itself
- Compactness—Hydraulic motors are more compact than electrical motors of equal horsepower
- Economy—Low installation cost; low operating cost
- Safety—Hydraulic systems have fewer moving parts and present fewer potential hazards than mechanical systems with gears and chains

b. Disadvantages—Any two of the following:

- Safety—High pressure is potentially dangerous
- Cleanliness—System must be kept very clean to prevent excessive wear of the components
- Leaks—With almost any system under pressure, leaks are inevitable

Objective 4

a. 2
b. 3
c. 1
d. 6
e. 5
f. 7
g. 4

Answers to Written Test

Objective 5	a. 4 b. 5 c. 2 d. 1 e. 3
Objective 6	a. Cannot b. Can c. Can d. Equally e. Unequal
Objective 7	a. 5 psi b. 6 psi
Objective 8	b, c
Objective 9	a. Vented to atmosphere b. Pressurized and sealed
Objective 10	a. Return line b. Filler cap c. Fluid level gauge d. Baffle e. Intake filter screen f. Reservoir outlet g. Drain plug h. Inspection plate
Objective 11	Any two of the following: a. Too much speed b. Too much heat c. Too much pressure d. Too much contamination
Objective 12	a, d
Objective 13	Any two of the following: a. Prolong the life of the system b. Reduce down time c. Reduce or eliminate needless failures

Objective 14

Any four of the following:

a. Check fluid level.
b. Inspect for leaks.
c. Inspect hoses, lines, and drive components for excessive wear.
d. Check for proper system operation.
e. During operation, watch and listen to system to check for:

    - Unusual sounds
    - Abnormal flow through relief valve—Often indicated by a high-pitched sound
    - Cavitation—Often indicated by a low-pitched sound

f. Change filter and fluid according to manufacturer's recommendations.

Objective 15

Any two of the following:

a. Keep the oil clean.
b. Keep the system clean.
c. Keep the work area clean.
d. Use oil recommended by the manufacturer when changing or adding oil.

Objective 16

Discussion should include at least three of the following safety hazards and three of the following safety practices (in student's own words).

a. Safety hazards

    - Components subjected to excessive pressure may explode.
    - Accidental release of trapped oil in hydraulic circuits supporting booms or attachments may cause these components to malfunction or fall suddenly.
    - Hot oil from leaks, disconnected lines, or reservoir drains can cause severe burns.
    - Pinhole leaks in high-pressure circuits can release potentially dangerous fluids.
    - Many hydraulic fluids are extremely flammable.
    - Some hydraulic fluids can irritate or burn when they contact the skin or eyes.

b. Safety practices

    - Support booms and lower attachments to ground before working on a hydraulic system.
    - Operate all control levers to check to see that hydraulic pressure has been relieved.
    - Loosen lines and components in a circuit slowly to relieve trapped pressure.
    - Stop equipment and repair leaks immediately.
    - Wear safety glasses and a safety helmet as required when working with any system under pressure.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 5.

☐ 4. **Go to** Shop area and have instructor show you various types of equipment that use hydraulics. Also, have instructor point out the components of a basic hydraulic system using actual equipment in the shop.

☐ 5. **Do** Assignment Sheet 1, "Draw a Block Diagram of A Simple Hydraulic System."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat steps 3, 5, and 6.

☐ 7. **Study** Information Sheet, Objectives 6 through 10.

☐ 8. **Go to** Shop area and have your instructor demonstrate basic hydraulic principles, and to show you the parts of a reservoir and demonstrate how to check for problems.

☐ 9. **Study** Information Sheet, Objectives 11 through 16.

☐ 10. **Observe** Demonstration of procedure to be used in completing Job Sheet 1. Ask instructor to review with you appropriate safety practices when working on a hydraulic system.

☐ 11. **Do** Job Sheet 1, "Perform General Maintenance Procedures on a Hydraulic System."

☐ 12. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 1 and repeat steps 11 and 12.

☐ 13. **Observe** Demonstration of procedure to be used in completing Job Sheet 2.

☐ 14. **Do** Job Sheet 2, "Change Hydraulic Fluid and Filter."

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, study the procedure outlined in Job Sheet 2 and repeat steps 14 and 15.

☐ 16. **Check** With instructor for any additional assignments to be completed.

☐ 17. **Do** Additional assignments listed below.

____

____

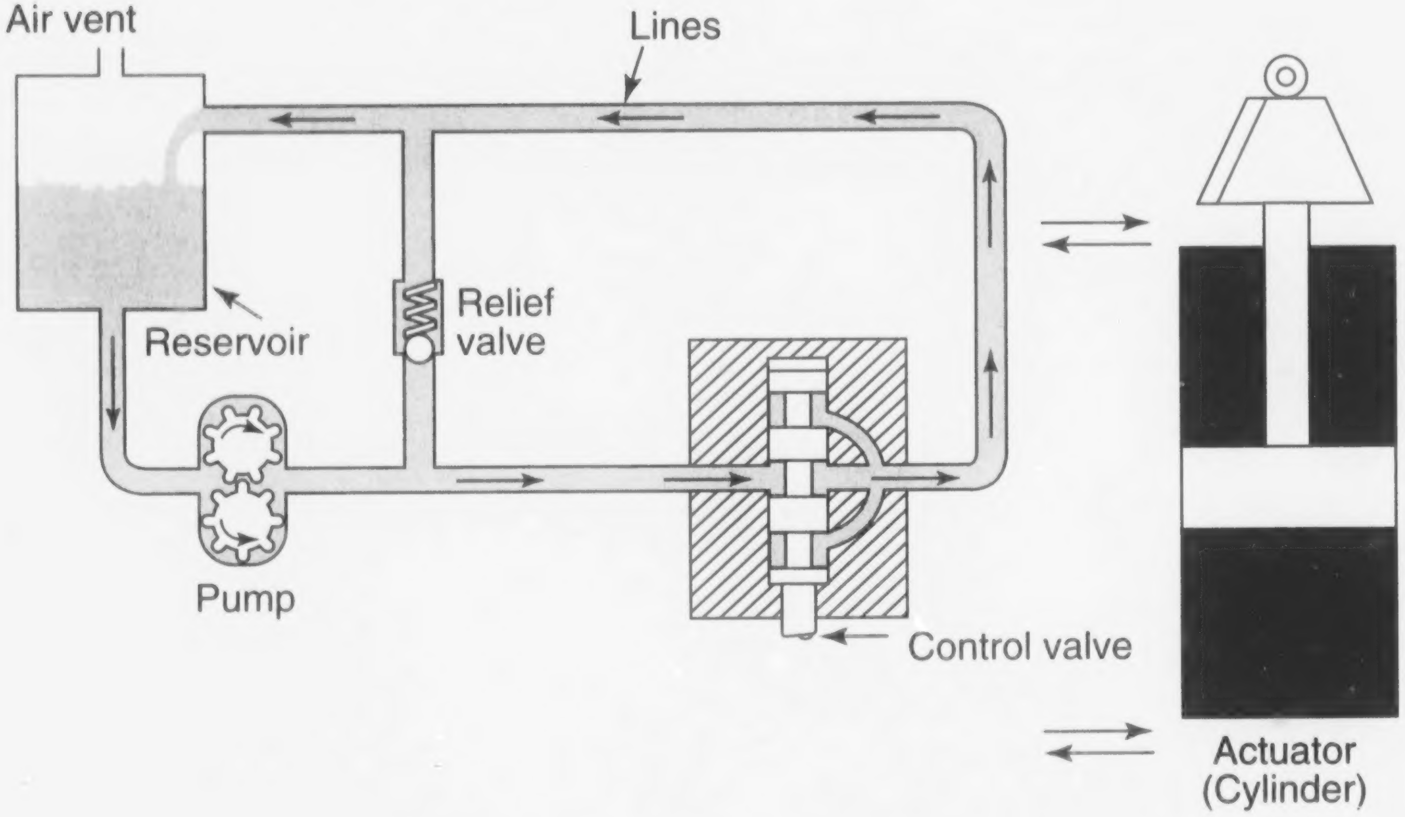
____

☐ 18. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

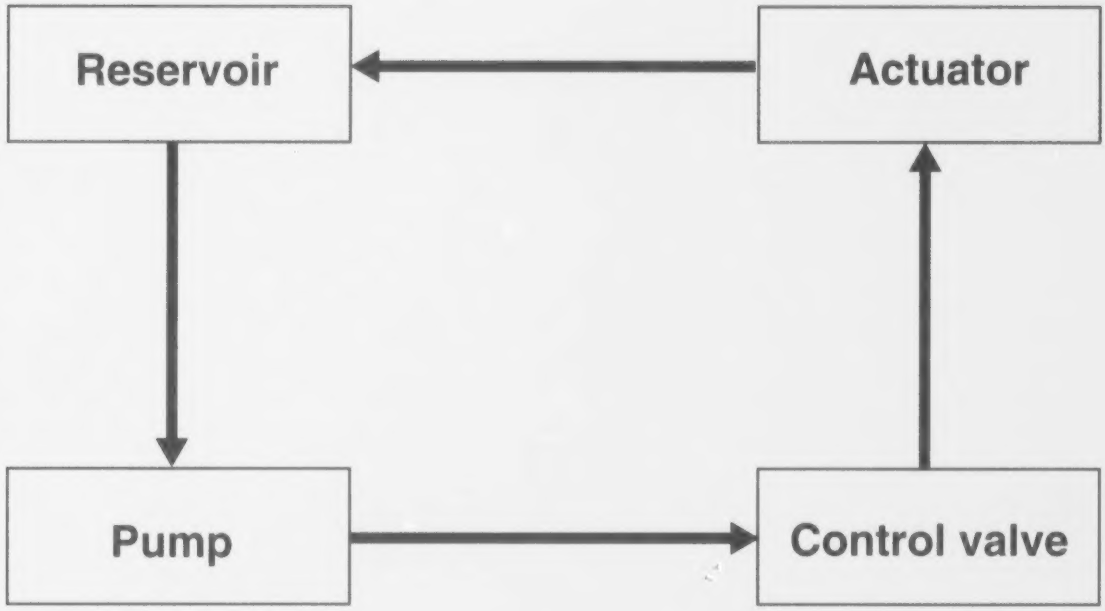
☐ 19. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Components of a Hydraulic System


Air vent
Lines
Reservoir
Relief valve
Pump
Control valve
Actuator (Cylinder)

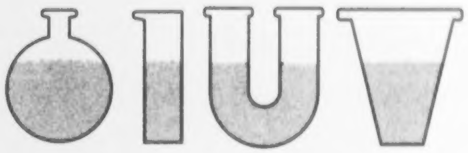
Simple Hydraulic System Block Diagram


Reservoir
Actuator
Pump
Control valve

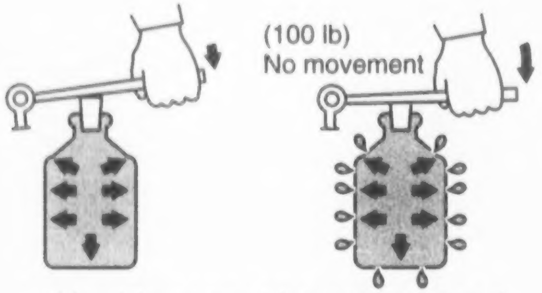
372

TM 2

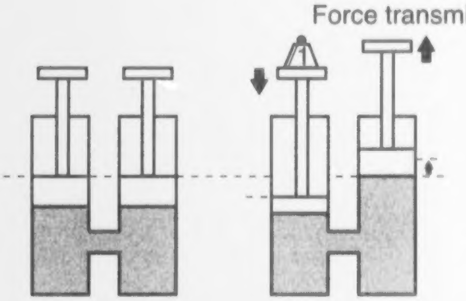
Basic Principles of Hydraulics



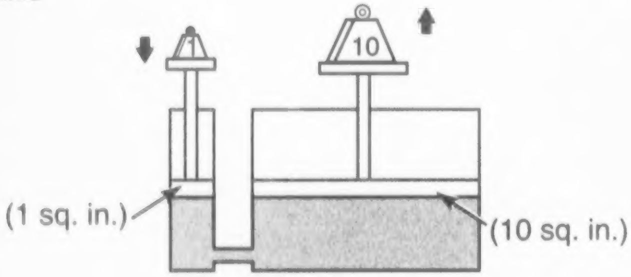
Liquids have no shape of their own


(100 lb)
No movement

Liquids cannot be compressed

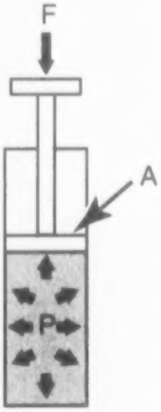

Force transmitted
1

Liquids can be used
to transmit force


1
10
(1 sq. in.)
(10 sq. in.)

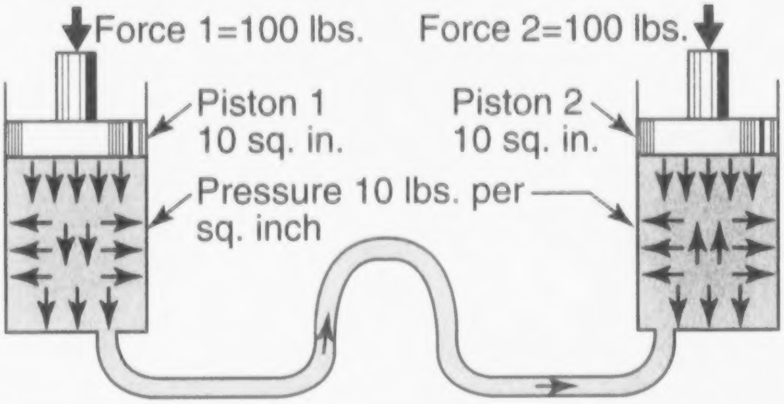
Liquids can be used
to multiply force

Courtesy of Deere and Co.

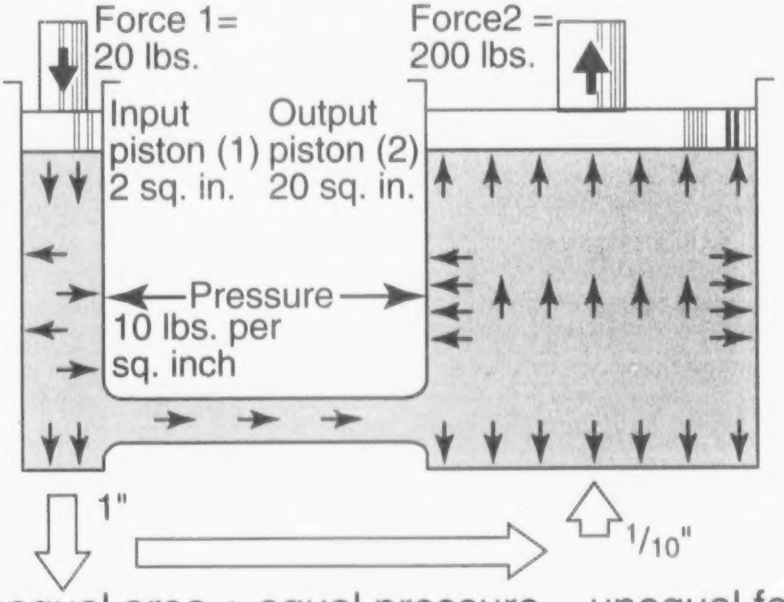


Pressure set up in a confined liquid acts
equally in all directions—Pascal's Law

Application of Hydraulic Principles

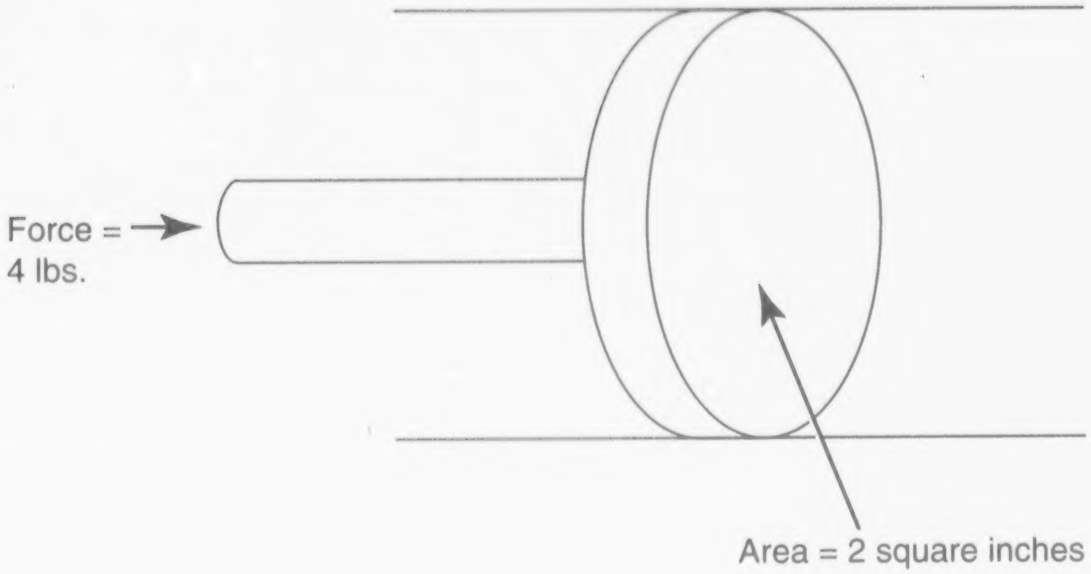

Force 1=100 lbs.
Force 2=100 lbs.
Piston 1
10 sq. in.
Piston 2
10 sq. in.
Pressure 10 lbs. per
sq. inch

Equal area + equal pressure = equal force


Force 1=
20 lbs.
Force2 =
200 lbs.
Input
piston (1)
2 sq. in.
Output
piston (2)
20 sq. in.
Pressure
10 lbs. per
sq. inch
1"
1/10"

Unequal area + equal pressure = unequal force

Calculating Pressure


Force = 4 lbs.
Area = 2 square inches

$$\text{Pressure} = \frac{4 \text{ lbs.}}{2 \text{ sq in.}} = 2 \text{ PSI.}$$

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 3C–3
Written Test 3C–9
Answers to Written Test 3C–23
Learning Activities Sheet 3C–29

Transparency Masters

1—Arc Welding Circuit 3C–33
2—Parts of the Arc Welding Process 3C–35
3—AWS Electrode Classification System 3C–37
4—Types of Welds 3C–39
5—Types of Weld Joints 3C–41
6—Methods of Striking an Arc 3C–43
7—Types of Electrode Motions (Rod Manipulations) 3C–45
8—Positions Used in Arc Welding 3C–47
9—Parts of an Oxyacetylene Outfit 3C–49
10—Parts of an Oxyacetylene Outfit (Continued) 3C–51
11—Types of Oxyacetylene Flames 3C–53
12—Oxyacetylene Braze Welded Butt Joint 3C–55
13—Parts of a Torch Body and Cutting Attachment 3C–57

Student Components

Student Page

Objective Sheet 3C–3
Information Sheet 3C–5

Student Supplements

1—Covered Electrodes for SMAW of Carbon Steel (per AWS A5.1) 3C–27
2—Recommended Amperages for Electrodes by Type and Diameter (Current Range, A) 3C–29
3—Oxyacetylene Welding Parameters 3C–31
4—Parameters for Oxyfuel Cutting 3C–33

Unit Contents

Job Sheets

1—Start, Stop, and Restart a Bead 3C–35
2—Construct a Pad Weld 3C–39
3—Construct a Butt Weld 3C–43
4—Construct a Lap-Joint Fillet Weld in the Flat Position 3C–45
5—Construct a T-Joint Fillet Weld in the Flat Position 3C–47
6—Set Up Equipment for Oxyacetylene Welding/Cutting 3C–49
7—Turn On, Light, Adjust, and Shut Down Oxyacetylene Welding Equipment 3C–53
8—Braze Weld a Lap Joint 3C–57
9—Cut Mild Steel at a 90° Angle, Stop, and Restart the Cut 3C–61
10—Cut Round Stock 3C–65

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Suggested Activities

- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Discuss safety rules to follow when welding, as well as rules to follow when others are welding in the area. Stress the importance of wearing the appropriate safety gear when welding. Safety glasses/goggles should be worn at all times by anyone in the welding area of the shop.
- Discuss times when arc welding will be used in the diesel shop and when oxyacetylene welding or cutting would be more appropriate.
- Demonstrate how to use the arc welding machine available in the diesel shop. Show how to set up, operate, and shut down. Also show how current flows in the arc welding circuit.
- Show examples of different types of welding electrodes (rods), and discuss their recommended uses. Refer to Student Supplements for more information. These may be enlarged and posted in the welding area of the shop.
- Demonstrate how to make the various types of welds and weld joints discussed in this unit (Objectives 14 and 15). Demonstrate eye-hand coordination and dexterity, and discuss how students can improve their skills with practice.
- Provide special assistance to left-handed students because most procedures are written for right-handers.
- Discuss what makes a good weld, and show examples of good and bad welds. Emphasize the importance of visually inspecting all welds and redoing all bad welds. Customers expect quality work.
- Show the parts of the oxyacetylene outfit. Call attention to the colors used for oxygen and acetylene and the differences in their threaded fittings. Demonstrate how to set up, operate, and shut down the system. Also demonstrate the different types of flames so students can see the neutral flame to use for most work.
- Demonstrate the emergency shutdown procedure to use in the event of backfire or flashback. Check with the manufacturer of your oxyacetylene outfit for their recommendations. However, emphasize to students that the most important concern is to get both valves closed quickly.
- Discuss times when braze welding will be used, and discuss any special precautions that students should know before brazing.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Connor, Leonard P., ed. *Welding Handbook, 8th edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.
- Fortney, Clarence and Mike Gregory. *Fundamentals of Welding*, 2nd edition. Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1992.
- Fortney, Clarence and Mike Gregory. *Oxyacetylene Welding and Cutting*, 2nd edition. Stillwater, OK: Mid-America Vocational Curriculum Consortium, Inc., 1992.
- Gellerman, Mike. *Welding Fundamentals*. Delmar Publishers, 1995.
- O'Brien, R. L., ed. *Welding Handbook, 8th edition, Vol. 2, Welding Processes*. Miami, FL: American Welding Society, 1991.
- *Safety in Welding, Cutting, and Allied Processes* (Z49.1-94). Miami, FL: American Welding Society, 1994.

Suggested Supplemental Resources

Print Media

- *MIG-GMAW Welding*. General Motors manual that provides information about welding processes including oxyacetylene welding, sheet metal, gas welding, brazing, and MIG welding. (Item# P-9324). Available from:

  Automotive Service Association
  P.O. Box 929
  Bedord, TX 76095-0929
  800-272-7467 or 817-283-6205

- *Weld Failure Analysis* (SEBV0566), 23-page book. (1991). Available from:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

Electronic Media

- *Welding Safely—The Way the Pros Do It*. Videotape produced by the National Electrical Manufacturers Association. Available from:

  American Welding Society, Ordering Department
  550 Northwest LeJeune Road
  P.O. Box 351040
  Miami, FL 33135
  800-334-9353

- *Basic Welding.* 2 CD-ROMs available separately or together in one value package. Covers basic principles, equipment, gases, and electrodes. Includes pre and post test questions and guides.
- *Personal Safety & Proper Attitude.* Videocassette or CD-ROM. Describes importance of personal safety when using welding machines and ways to avoid injuries.
- *Safe Use of Equipment.* Videocassette or CD-ROM. Introduces current, amperage, voltage, and resistance.
- *Shielded Metal-Arc Welding.* Videocassette or CD-ROM. Introduces basic principles, types of electrodes, and striking an arc.
- *Operator and Fire Safety.* Videocassette or CD-ROM. Describes noxious smoke, fumes, potential fire hazards, fire extinguishers, and housekeeping.
- *Cylinder Safety.* Videocassette or CD-ROM. Covers how to store, handle, and move oxygen and acetylene cylinders. Also how to detect leaks.

  The above are available from:

  Bergwall Productions Inc.
  540 Baltimore Pike
  P.O. Box 2400
  Chadds Ford, PA 19317-9904
  800-645-3565 or 610-388-0400

- *Safe Handling and Storage of Compressed Gases.* Slide/audio cassette or 1/2″ VHS videotape. Available from:

  Compressed Gas Association
  1235 Jefferson Davis Highway
  Arlington, VA 22202
  703-979-0900

- *Oxyacetylene Welding.* Covering safety, setup, fillet and groove welds with various joints, braze welding, and silver brazing. 12 filmstrips or 12 videocassettes covering four units of instruction. Available from:

  DCA Educational Products
  Kellers Church Road
  P.O. Box 338
  Bedminister, PA 18910
  800-345-3548 or 215-795-2841

Suggested Activities

- *Oxyacetylene Welding, Cutting, Brazing.* Covers safety, basics, and many applications (with instructor's guide). 16mm film and 1/2" VHS videotape. Available from:

  Hobart School of Welding Technology
  Trade Square East
  Troy, OH 45373
  513-332-5217

- *Oxy-Fuel Safety, It's Up To You.* Covers equipment care, hazards of reverse flow and flashback. 16mm film or 1/2" VHS videotape. Available from:

  Victor Equipment Company
  Film Communications
  10466 Plano Road
  Dallas, TX 75238
  214-340-2579

- *Gas Welding Equipment, Gas Cutting, Torch and Tip Care* (SEVN9050), 28-minute video. (1973) Available from:

  Caterpillar Service Training
  600 W. Washington St., Bldg. JJ
  East Peoria, IL 61630

- FOS Welding set of 147 slides (FOS5207S-152). Available from:

  Deere & Company
  Distribution Service Center
  P.O. Box 186
  Moline, IL 61266-1086

333

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their definitions. Definitions continue on the next page.

1. Acetylene
2. Alloy
3. American Welding Society
4. Arc welding
5. Bevel
6. Braze welding
7. Butt joint
8. Ductile
9. Filler rod
10. Flint lighter
11. Fusion welding
12. Lead
13. Molten
14. Oxide
15. Oxidize
16. Oxyacetylene cutting
17. Oxyacetylene welding
18. Oxygen
19. Pass
20. Puddle
21. Purge
22. Rippled

_____ a. Substance produced when oxygen is combined with another element

_____ b. Bronze rod with characteristics similar to base metal

_____ c. Single longitudinal progression of a welding operation along a joint or weld deposit

_____ d. Heating base metal to a dull red and depositing a bead over the seam (joint) with a filler rod, without melting the base metal

_____ e. Cables leading from ground clamp and holder to machine

_____ f. Substance composed of two or more metals or a metal and a nonmetal fused together

_____ g. Joining of two or more pieces of metal by fusion process that uses an arc to heat the metal

_____ h. Striker used to ignite torch

_____ i. Angular cut made on the vertical edge of base metal to allow better weld penetration

_____ j. Capable of being drawn or stretched

Written Test

____ k. Colorless, gaseous hydrocarbon used in cutting and welding

____ l. Portion of a weld that is molten at the place heat is applied

____ m. Element that is normally a colorless, odorless, and tasteless gas; used in combination with other substances in cutting and welding

____ n. Liquefied by heat

____ o. Weld between two metal joints on the same plane

____ p. Joining pieces of metal by heating adjoining edges to the fusion point and allowing them to flow or run together and then cool

____ q. Method of cutting metal using an oxyacetylene torch to preheat the metal

____ r. To remove any foreign material from a system or component by flushing with the gas used in that system

Objective 2

Distinguish between correct and incorrect safety precautions to follow when welding by circling "Do" or "Don't" as appropriate.

a. (Do, Don't) use locking clamps or pliers to handle hot metal.

b. (Do, Don't) weld around combustible or flammable materials.

c. (Do, Don't) use only hoses designated for oxygen and acetylene.

d. (Do, Don't) leave arc welding electrode holder on welding table or in direct contact with grounded metal.

e. (Do, Don't) look at arc or flame or reflection of arc or flame without eye protection.

f. (Do, Don't) disconnect plug before checking arc welding machine.

g. (Do, Don't) use matches to light oxyacetylene torch.

h. (Do, Don't) use compressed oxygen to clean off clothing.

i. (Do, Don't) cut or weld two feet from cylinders.

j. (Do, Don't) use soapsuds and paintbrush to test oxyacetylene connections for leaks.

k. (Do, Don't) chip slag without wearing safety goggles.

l. (Do, Don't) cut or weld directly on gravel or concrete.

m. (Do, Don't) breathe toxic fumes.

n. (Do, Don't) breathe compressed oxygen directly from cylinder or hose.

o. (Do, Don't) use acetylene at pressures higher than 15 pounds per square inch.

p. (Do, Don't) use oil on regulators, torches, fittings, or any equipment surface that may come in contact with oxygen.

q. (Do, Don't) dispose of arc welding electrode stubs properly.

r. (Do, Don't) cut or weld on containers that have been used to store combustible materials.

Objective 3

Match welding materials with their descriptions.

1. Cast iron
2. Low-carbon steel
3. Mild steel

_____ a. Steel containing from 0.2 to 0.5 percent carbon

_____ b. Commercial alloy of iron, carbon, and silicon that is cast in a mold and is hard, brittle, nonmalleable, and incapable of being hammer-welded

_____ c. Steel containing 0.2 percent or less carbon

Objective 4

Complete the following statements concerning the basic arc welding circuit by filling in the blanks with the correct answers.

a. The current for the arc is supplied by _____________________ with two cables, one of which terminates in _____________________, the other in _____________________ which is connected to the base metal.

b. Current arcs from _____________________ to the ground clamp, heating the base metal and melting the _____________________, which drips into and fills the gaps between the pieces of base metal.

Written Test

Objective 5

Match the parts of the arc welding process with their descriptions.

1. Angle of electrode
2. Arc
3. Base metal
4. Crater
5. Direction of travel
6. Electrode
7. Flux
8. Gaseous shield
9. Heat line
10. Penetration
11. Slag
12. Weld
13. Wire core

_____ a. Flow of electric current across a narrow gap, usually from tip of electrode to base metal

____ b. Waste materials (impurities) that form on the surface of molten metal during the welding or cutting process

____ c. Distance from original surface of base metal to that point at which fusion ceases

____ d. Gas given off by melting of electrode flux

____ e. Metal rod that conducts a current from electrode holder to base metal in arc welding

____ f. That part of base metal altered by heat from welding, brazing, or cutting operations

____ g. Coating on outside of electrode; chemical used to promote fusion during welding process

____ h. Area joined by the process

____ i. Depression at termination of weld

Objective 6

Name two types of arc welding machines.

a. ____

b. ____

Objective 7

Distinguish between true and false statements by placing a "T" or "F" next in the blanks as appropriate.

a. Reverse (+) polarity (RP)—Current flows from electrode to base metal

b. Straight (–) polarity (SP)—Current flows from base metal to electrode

c. Type of electrode is a factor that determines correct polarity.

Objective 8

Describe the effects of raising and lowering welding machine amperes.

a. ____

b. ____

Objective 9

Match the common types of arc welding electrodes with their descriptions.

1. Cutting
2. Low hydrogen
3. Mild steel
4. Nickel

_____ a. For use on all cast iron; finished weld is machinable

_____ b. General purpose contact type; joints most hard-to-weld steels (high sulfur, low alloy, medium and high carbon, and cold rolled)

_____ c. All-purpose for most general repair work on autos, trucks, farm equipment, pipe, tanks, and structural steel

_____ d. Cuts metals quickly and easily; does not require oxygen or special equipment

Objective 10

Select common diameter sizes of arc welding electrodes by placing an "X" in the appropriate blanks.

_____ a. 3/16 inch

_____ b. 2/7 inch

_____ c. 1/8 inch

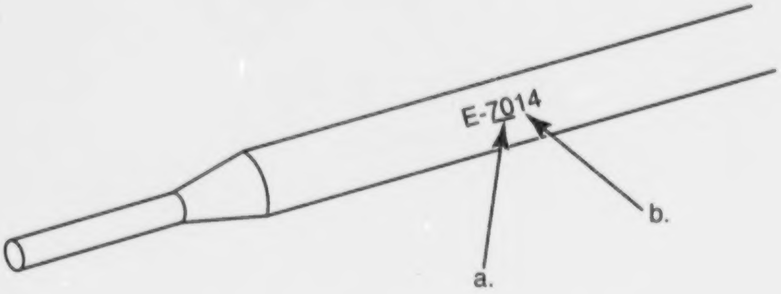
_____ d. 5/32 inch

_____ e. 4/29 inch

Written Test

Objective 11

Interpret the means of AWS electrode classification numbers shown on the electrode below.



a. ____

b. ____

Objective 12

List two factors to consider when selecting electrodes.

a. ____

b. ____

Objective 13

Select purposes of electrode flux by placing an "X" in the appropriate blanks.

_____ a. Stabilize arc

_____ b. Decrease welding speed

_____ c. Form slag and slow down cooling

_____ d. Increase impurities in puddle

_____ e. Add alloy elements to weld metal

_____ f. Shield molten puddle from air

Objective 14

Match types of welds with their descriptions.

1. Basic weld	3. Groove weld
2. Fillet weld	4. Tack weld

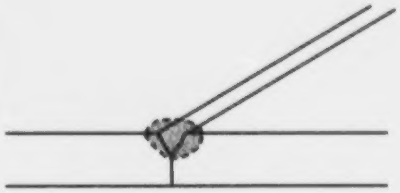
_____ a. Weld made in groove formed by two beveled pieces of metal

_____ b. Weld made by one pass of electrode

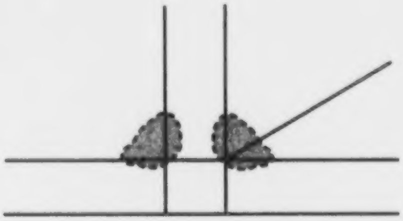
_____ c. Weld made in corner or angle formed by two pieces of metal with welded surfaces at approximately 90-degree angles to each other

Objective 15

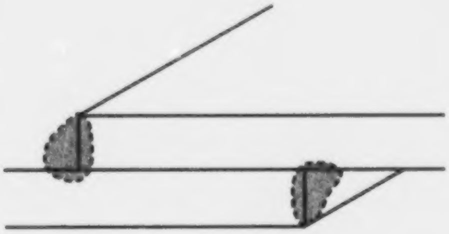
Identify the following types of weld joints. Write your answers in the blanks provided.



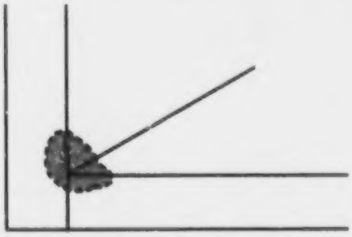
a. ____________________



b. ____________________



c. ____________________



d. ____________________

Objective 16

Select characteristics of good welds by placing an "X" in the appropriate blanks.

____ a. Rough edges

____ b. Correct bead size

____ c. Uneven ripple

____ d. Slight crown

____ e. Clean, bright weld

____ f. Even penetration

Objective 17

List three reasons for poor welds.

a. ____________________

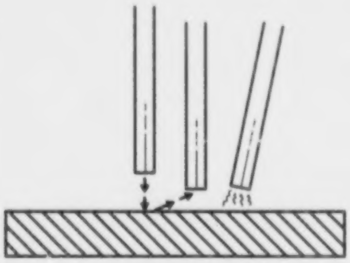
b. ____________________

c. ____________________

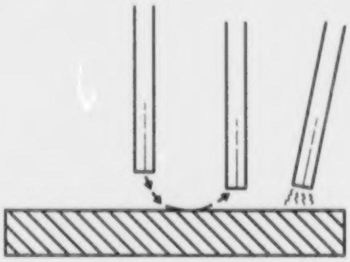
Written Test

Objective 18

Identify the following methods of striking an arc. Write your answers in the blanks provided.



a. ____________________



b. ____________________

Objective 19

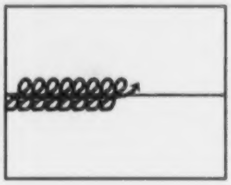
Select characteristics of proper arc length by placing an "X" in the blanks next to the true statements.

_____ a. Arc length making steady hum at welder and frying sound at arc.

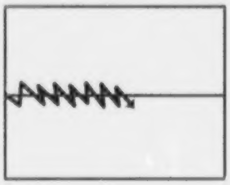
_____ b. End of the electrode is at a shorter distance from base metal than the diameter of electrode.

Objective 20

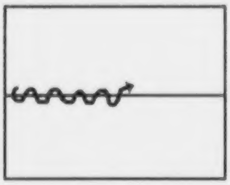
Identify the following types of electrode motions. Write your answers in the blanks provided.



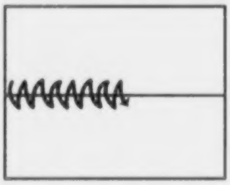
a. ____________________



b. ____________________



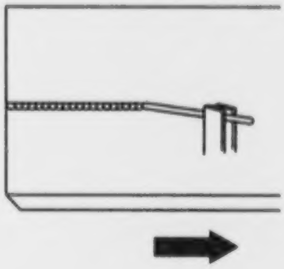
c. ____________________



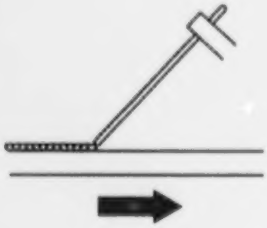
d. ____________________

Objective 21

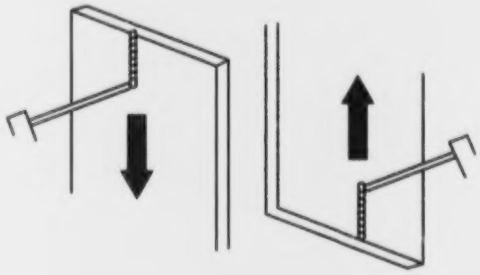
Identify the following positions used in arc welding. Write your answers in the blanks provided.



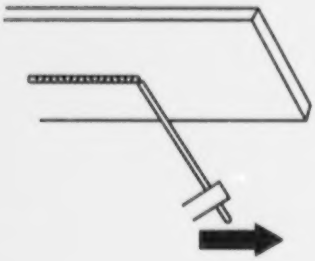
a. ______________________



b. ______________________



c. ______________________

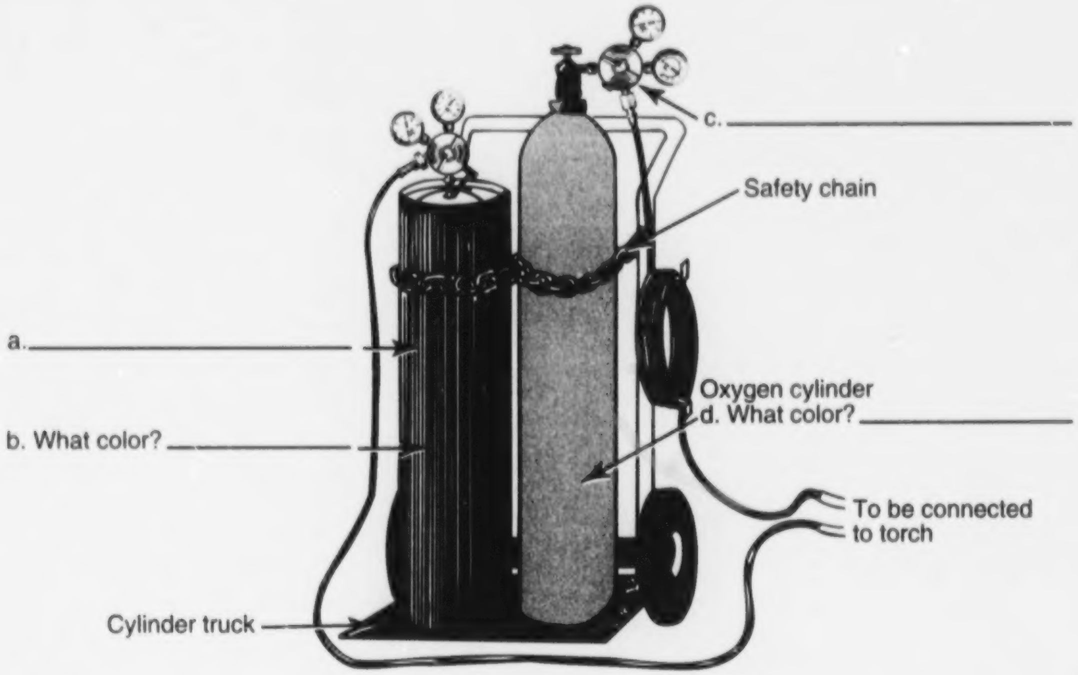


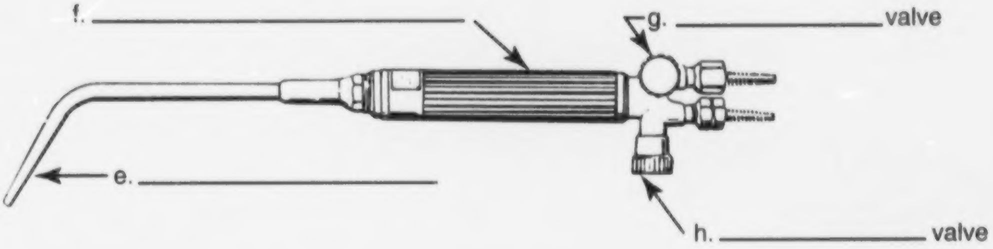
d. ______________________

Written Test

Objective 22

Label the parts of an oxyacetylene outfit. Write your answers in the blanks provided in the drawing.


c. ____________
Safety chain
a. ____________
b. What color? ____________
Oxygen cylinder
d. What color? ____________
To be connected to torch
Cylinder truck


f. ____________
g. ____________ valve
e. ____________
h. ____________ valve

Objective 23

Name the factors that determine selection of welding tip size.

a. ____________________

b. ____________________

Objective 24

Arrange in order the stages of oxyacetylene torch combustion by placing the correct sequence numbers (1-5) in the appropriate blanks.

____ a. Mixture burns at torch tip.

____ b. Operator ignites acetylene gas with spark from flint lighter.

____ c. Two cylinders provide pressure-regulated acetylene and pressure-regulated compressed oxygen.

____ d. Separate, flexible hoses carry gases to the torch.

____ e. Operator opens oxygen torch valve, and gases are mixed inside torch.

Objective 25

Distinguish among types of oxyacetylene flames by placing the following letter next to the correct descriptions:

- C = Carburizing flame
- N = Neutral flame
- O = Oxidizing flame

____ a. Identified by clear, well-defined white cone

____ b. Is hottest flame

____ c. Burns excess of acetylene

____ d. Identified by short, white inner cone

____ e. Recommended for brazing

____ f. Preferred for most welding tasks

____ g. Introduces carbon into weld, causing hardening of the metal which weakens weld

Objective 26

Define flashback and backfire.

a. Flashback— ____

____

b. Backfire— ____

____

Written Test

Objective 27

Arrange in order the steps to follow in case of flashback by placing the correct sequence numbers (1-8) in the appropriate blanks.

_____ a. Release oxygen pressure-regulating screw.

____ b. Light torch.

____ c. Close oxygen torch valve.

____ d. Release acetylene pressure-regulating screw.

____ e. Close oxygen preheat valve.

____ f. Preferred for most welding tasks.

____ g. Reset regulator pressures.

____ h. Close acetylene torch valve.

Objective 28

Select causes of backfire by placing an "X" in the appropriate blanks.

_____ a. Dirty tip

____ b. Tight cutting tip

____ c. Not enough acetylene or oxygen pressure for the tip size used

____ d. Bad o-ring in torch body

____ e. Cutting tip is not hot enough

Objective 29

Discuss three advantages and three disadvantages of oxyacetylene braze welding.

a. Advantages

1) ______________________________

2) ______________________________

3) ______________________________

b. Disadvantages

1) ______________________________

2) ______________________________

3) ______________________________

Objective 30 Discuss one reason it is important to have a chemically clean metal surface in braze welding.

____

____

Objective 31 List the methods of removing oxides from a metal surface.

a. ______________________________________

b. ______________________________________

Objective 32 Explain the following reactions of molten bronze at different temperatures.

a. Correct— ________________________________

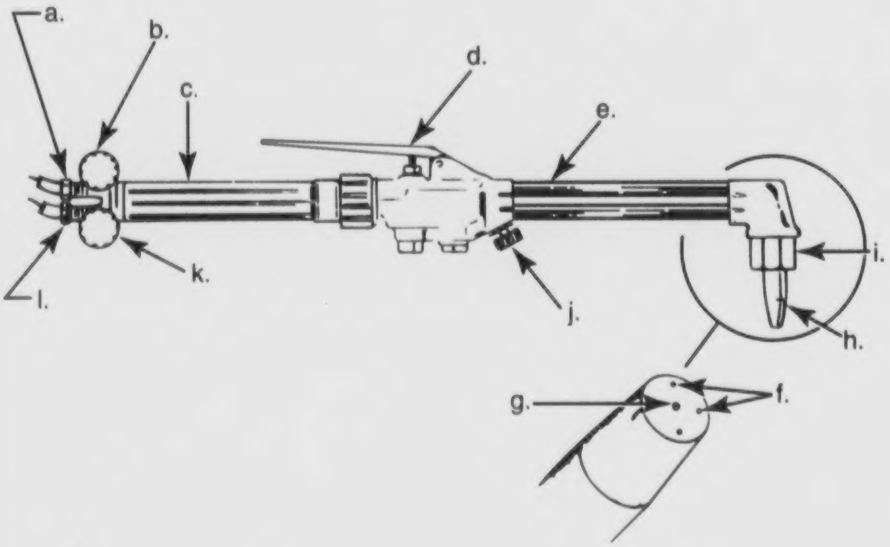
b. Too hot— ________________________________

c. Too cold— _______________________________

Written Test

Objective 33

Identify the following parts of a torch body and cutting attachment. Write your answers in the blanks provided.



a. ______________________ b. ______________________

c. ______________________ d. ______________________

e. ______________________ f. ______________________

g. ______________________ h. ______________________

i. ______________________ j. ______________________

k. ______________________ l. ______________________

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 14
b. 9
c. 19
d. 6
e. 12
f. 2
g. 4
h. 10
i. 5
j. 8
k. 1
l. 20
m. 18
n. 13
o. 7
p. 11
q. 16
r. 21

Objective 2

a. Do
b. Don't
c. Do
d. Don't
e. Don't
f. Do
g. Don't
h. Don't
i Don't
j. Do
k. Don't
l. Don't
m. Don't
n. Don't
o. Don't
p. Don't
q. Do
r. Don't

Objective 3

a. 3
b. 1
c. 2

Objective 4

a. A welding machine, the electrode, a ground clamp
b. The base metal, electrode's metal core

Objective 5

a. 2
b. 11
c. 10
d. 8
e. 6
f. 9
g. 7
h. 12
i. 4

Answers to Written Test

Objective 6	Any two of the following: a. Alternating-current (AC) transformer welder b. Direct-current (DC) welder c. Electric motor generator d. Engine generator e. AC/DC transformer rectifier
Objective 7	a. F b. F c. T
Objective 8	a. Raising amperes produces more heat, increases penetration. b. Lowering amperes produces less heat, decreases penetration.
Objective 9	a. 4 b. 2 c. 3 d. 1
Objective 10	a, c, d
Objective 11	a. Minimum tensile strength b. Indicates all positions
Objective 12	Any two of the following: a. Composition of base metal b. Thickness and shape of base metal c. Welding position d. Welding current
Objective 13	a, c, e, f
Objective 14	a. 3 b. 1 c. 2
Objective 15	a. Butt weld joint b. T (or Tee) weld joint c. Lap weld joint d. Corner weld joint

Answers to Written Test

Objective 16	b, d, e, f
Objective 17	Three of the following: a. Incorrect machine adjustment b. Too large or too small electrode c. Improper angle of electrode d. Improper preparation of base metal e. Incorrect arc length f. Improper movement of electrode
Objective 18	a. Tapping b. Scratching
Objective 19	a
Objective 20	a. Figure-eight motion b. Triangular motion c. Small oscillating motion d. Back-and-forth motion with half circle
Objective 21	a. Horizontal b. Flat c. Vertical d. Overhead
Objective 22	a. Açetylene cylinder b. Red or black with red markings c. Oxygen regulator d. Green or yellow with green labels e. Welding tip f. Torch handle g. Oxygen (valve) h. Acetylene (valve)
Objective 23	a. Size of welding electrode (rod) b. Thickness of base metal
Objective 24	a. 5 b. 3 c. 1 d. 2 e. 4

Answers to Written Test

Objective 25

a. N
b. O
c. C
d. O
e. O
f. N
g. C

Objective 26

Students may put the following definitions in their own words:

a. Flashback—Flame disappears inside torch body; at the same time, a squealing noise occurs and smoke and/or sparks are emitted from the torch tip
b. Backfire—Flame burns momentarily back into tip; then a loud snap or pop is emitted from the torch and the flame either goes out or continues to burn in a normal manner

Objective 27

a. 4
b. 8
c. 2
d. 5
e. 1
f. 6
g. 7
h. 3

Objective 28

a, c, d

401

Answers to Written Test

Objective 29

Discussion should include at least three of the following advantages and three of the following disadvantages (in student's own words):

a. Advantages of braze welding over fusion welding

  1) Main characteristics of base metal are less likely to be destroyed because it is not heated to molten state.
  2) Uses less gas
  3) Can be used to weld thin metals
  4) Can be used to weld malleable castings
  5) Increases speed of joining metals
  6) May be used to join different kinds of metals

b. Disadvantages of braze welding compared to fusion welding

  1) Cannot be used on metal where stress is a factor
  2) Bronze rod is expensive
  3) Is not recommended for parts that are raised to temperatures higher than melting point of bronze (1125°F to 1760°F), either in service or during heat treatment
  4) Bronze loses its strength at temperatures above 500°F.
  5) Will not bond unless base metal has corrosion-resistant properties similar to bronze

Objective 30

Discussion should include at least one of the following reasons (in student's own words):

a. Ensures that the molten bronze will adhere to base metal
b. Allows weld to form stronger bond on base metal
c. Allows bronze to flow smoothly and evenly over entire weld area

Objective 31

a. Mechanical means such as a wire brush or grinder
b. Chemical flux

Objective 32

a. Correct—Spreads evenly and flows over a considerable area
b. Too hot—Tends to boil and form little balls
c. Too cold—Forms into drops rather than flowing evenly over surface

Objective 33

a. Oxygen fitting (right-hand threads)
b. Oxygen torch valve
c. Torch handle
d. Oxygen cutting lever
e. Cutting assembly
f. Preheat orifices
g. Cutting orifice
h. Cutting tip
i. Tip nut
j. Oxygen preheat valve
k. Acetylene torch valve
l. Acetylene fitting (grooved nut, left-hand threads)

Unit 3-C Basic Welding and Cutting

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 6.

☐ 4. **Go to** Shop area and have instructor show you arc welding machines and materials that will be used in the diesel shop. Also, ask instructor to discuss safety rules and appropriate safety gear to wear when welding.

☐ 5. **Study** Information Sheet, Objectives 7 through 13, and Student Supplements 1 through 4.

☐ 6. **View** Examples of different types of welding electrodes (rods), and ask instructor to discuss their recommended uses.

☐ 7. **Study** Information Sheet, Objectives 14 through 21.

☐ 8. **Go to** Shop area and have instructor show you examples of good and bad welds and explain to you what makes a good weld and why it is important to check your work and redo bad welds if necessary.

☐ 9. **Observe** Demonstration of procedures to be used in completing Job Sheets 1 through 3. Ask instructor to review with you appropriate safety practices when welding.

☐ 10. **Do** Job Sheet 1, "Start, Stop, and Restart a Bead."

☐ 11. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 1 and repeat steps 10 and 11.

Learning Activities Sheet

☐ 12. **Do** Job Sheet 2, "Construct a Pad Weld."

☐ 13. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 2 and repeat steps 12 and 13.

☐ 14. **Do** Job Sheet 3, "Construct a Butt Weld."

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 3 and repeat steps 14 and 15.

☐ 16. **Observe** Demonstration of procedures to be used in completing Job Sheets 4 and 5.

☐ 17. **Do** Job Sheet 4, "Construct a Lap-joint Fillet Weld in the Flat Position."

☐ 18. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 19. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 4 and repeat steps 17 and 18.

☐ 19. **Do** Job Sheet 5, "Construct a T-joint Fillet Weld in the Flat Position."

☐ 20. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 21. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 5 and repeat steps 19 and 20.

☐ 21. **Study** Information Sheet, Objectives 22 through 33.

☐ 22. **Go to** Shop area and have your instructor show you the parts of the oxyacetylene outfit.

☐ 23. **Observe** Demonstration of procedures to be used in completing Job Sheets 6 and 7, and a demonstration of the different types of flames so you will know what a neutral flame should look like. Also, also your instructor to demonstrate the emergency shutdown procedure to use in the event of backfire or flashback.

☐ 24. **Do** Job Sheet 6, "Set Up Equipment for Oxyacetylene Welding/Cutting."

☐ 25. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 26. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 6 and repeat steps 24 and 25.

☐ 26. **Do** Job Sheet 7, "Turn On, Light, Adjust, and Shut Down Oxyacetylene Welding Equipment."

☐ 27. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 28. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 7 and repeat steps 26 and 27.

☐ 28. **Observe** Demonstration of procedures to be used in completing Job Sheet 8. Have instructor explain when braze welding may be used in a diesel shop and any precautions that should be taken before brazing.

☐ 29. **Do** Job Sheet 8, "Braze Weld Lab Joint."

☐ 30. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 31. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 8 and repeat steps 29 and 30.

☐ 31. **Observe** Demonstration of procedures to be used in completing Job Sheets 9 and 10.

☐ 32. **Do** Job Sheet 9, "Cut Mild Steel at a 90° Angle, Stop, and Restart the Cut."

Learning Activities Sheet

☐ 33. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 34. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 9 and repeat steps 32 and 33.

☐ 34. **Do** Job Sheet 10, "Cut Round Stock."

☐ 35. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 36. If the evaluation is not satisfactory, meet with the instructor to determine needed improvements, study the procedure outlined in Job Sheet 10 and repeat steps 34 and 35.

☐ 36. **Check** With instructor for any additional assignments to be completed.

☐ 37. **Do** Additional assignments listed below.

____

____

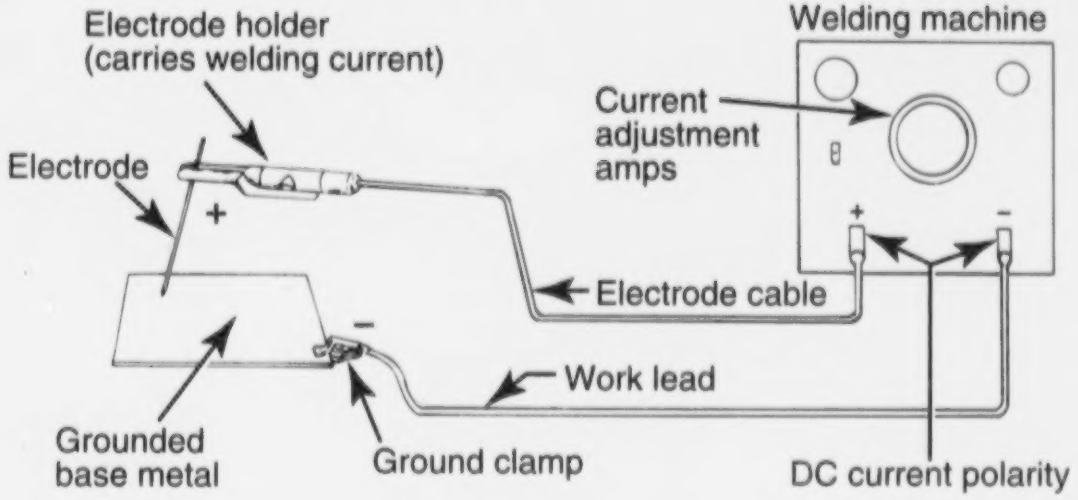
____

☐ 38. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

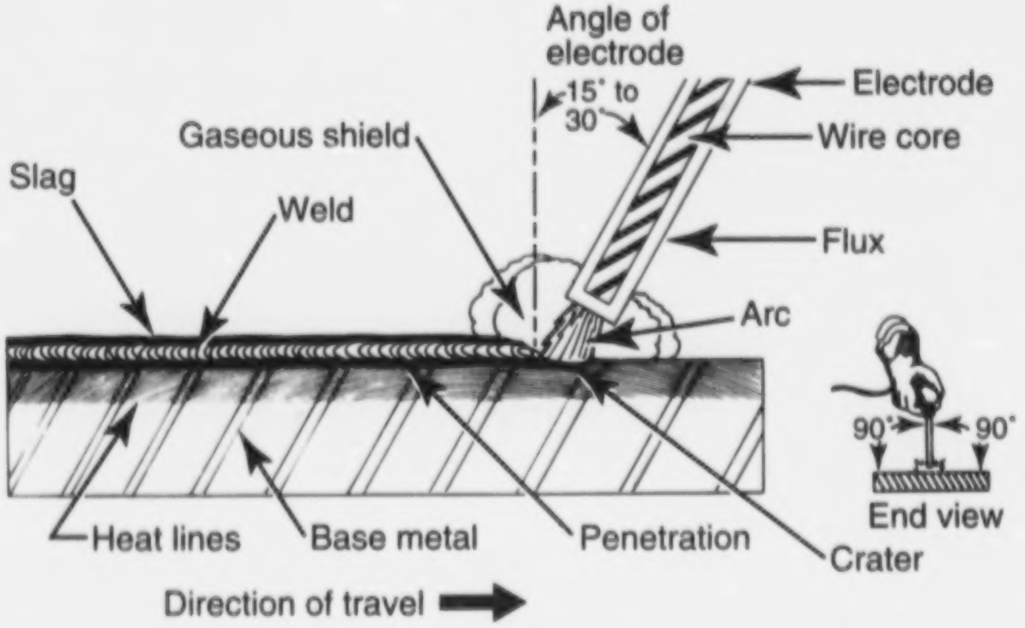
☐ 39. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

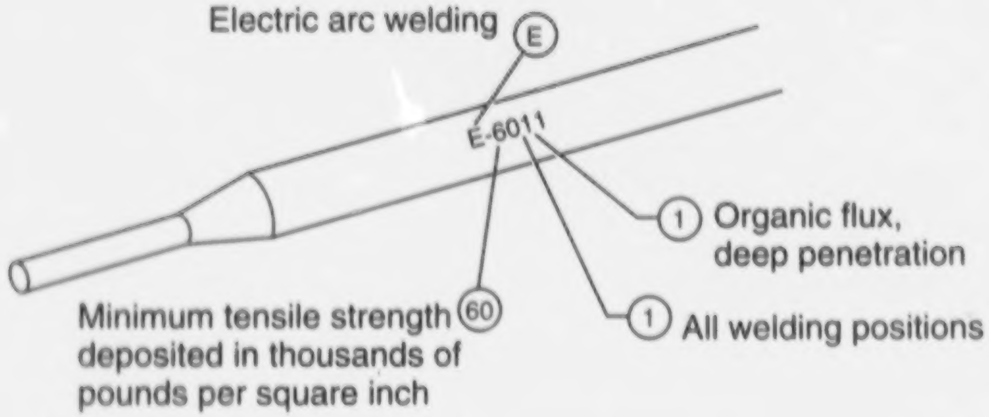
Arc Welding Circuit


Electrode holder
(carries welding current)
Welding machine
Current adjustment amps
Electrode
+
+
−
Electrode cable
−
Work lead
Grounded base metal
Ground clamp
DC current polarity

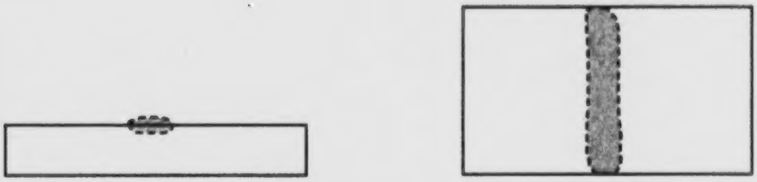
Parts of the Arc Welding Process


Angle of electrode
15° to 30°
Electrode
Wire core
Gaseous shield
Slag
Weld
Flux
Arc
90°
90°
End view
Heat lines
Base metal
Penetration
Crater
Direction of travel

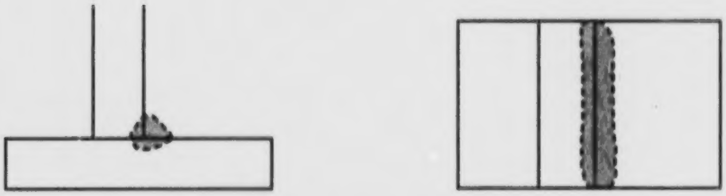
AWS Electrode Classification System


Electric arc welding
E
E-6011
1 Organic flux, deep penetration
60 Minimum tensile strength deposited in thousands of pounds per square inch
1 All welding positions

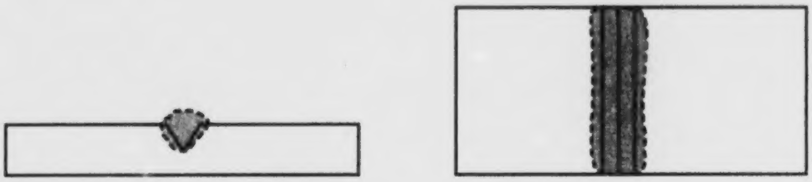
Types of Welds



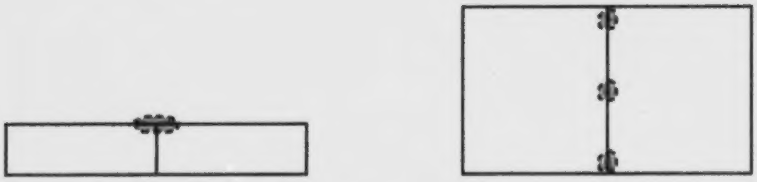
Basic weld



Fillet weld

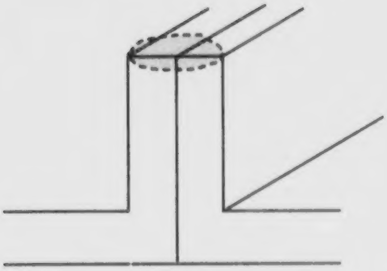


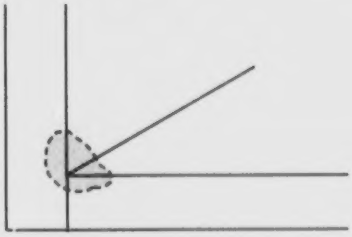
Groove weld

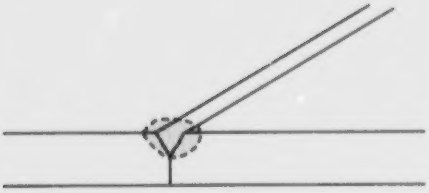


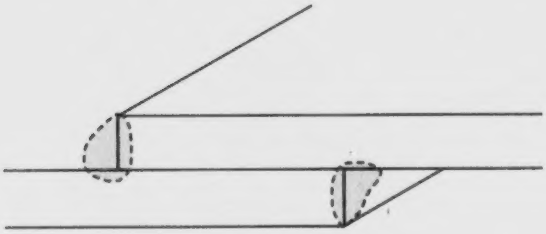
Tack weld

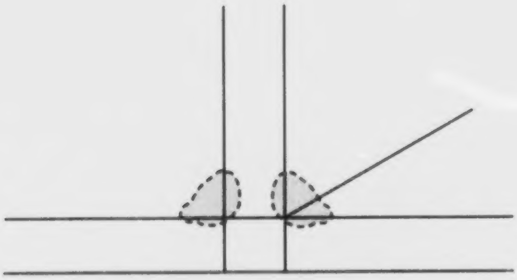
Types of Weld Joints


Edge weld joint

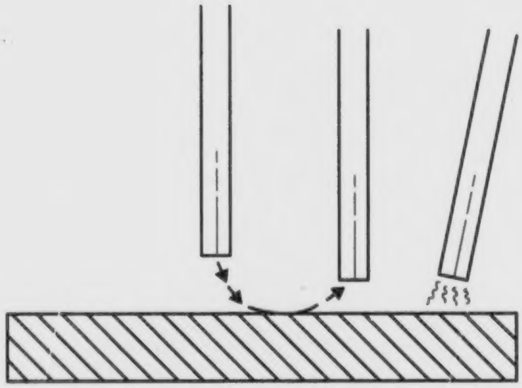

Corner weld joint


Butt weld joint

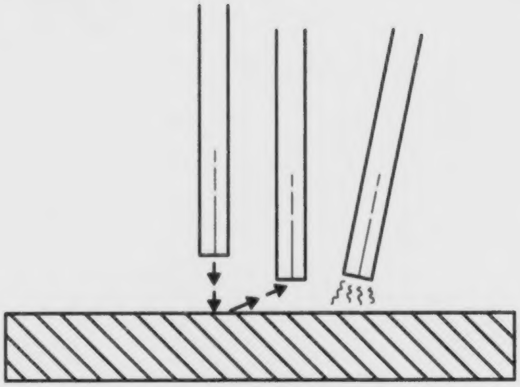

Lap weld joint


T (or tee) weld joint

Methods of Striking an Arc

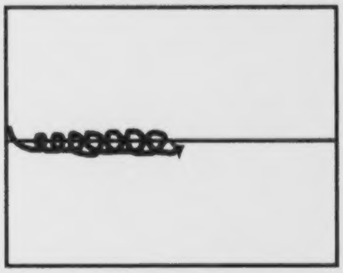


Scratching

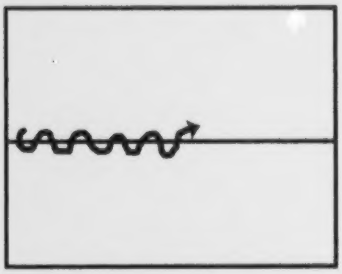


Tapping

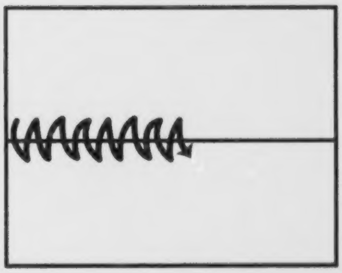
Types of Electrode Motions (Rod Manipulations)



Small oscillating motion



Small circular motion



Back-and-forth motion with half circle

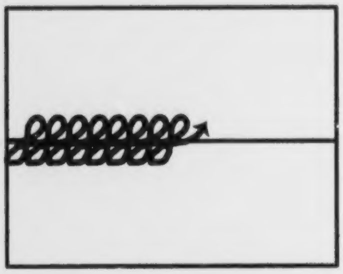
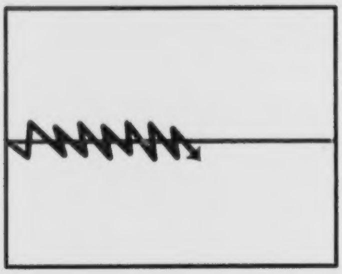
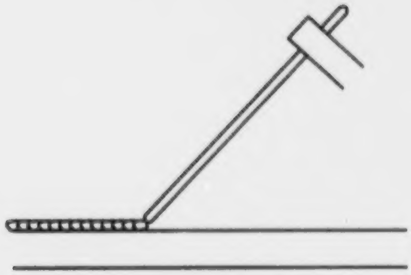


Figure-eight motion

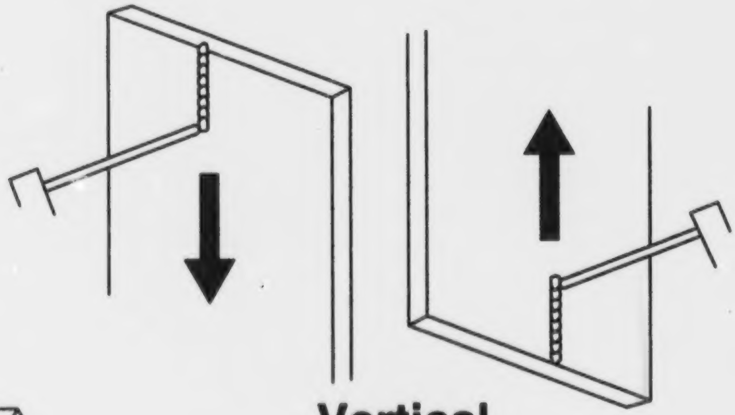


Triangular motion

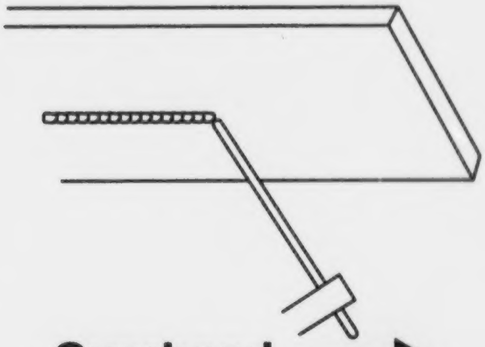
Positions Used in Arc Welding



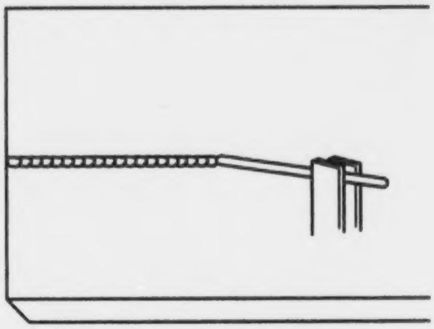
Flat



Vertical

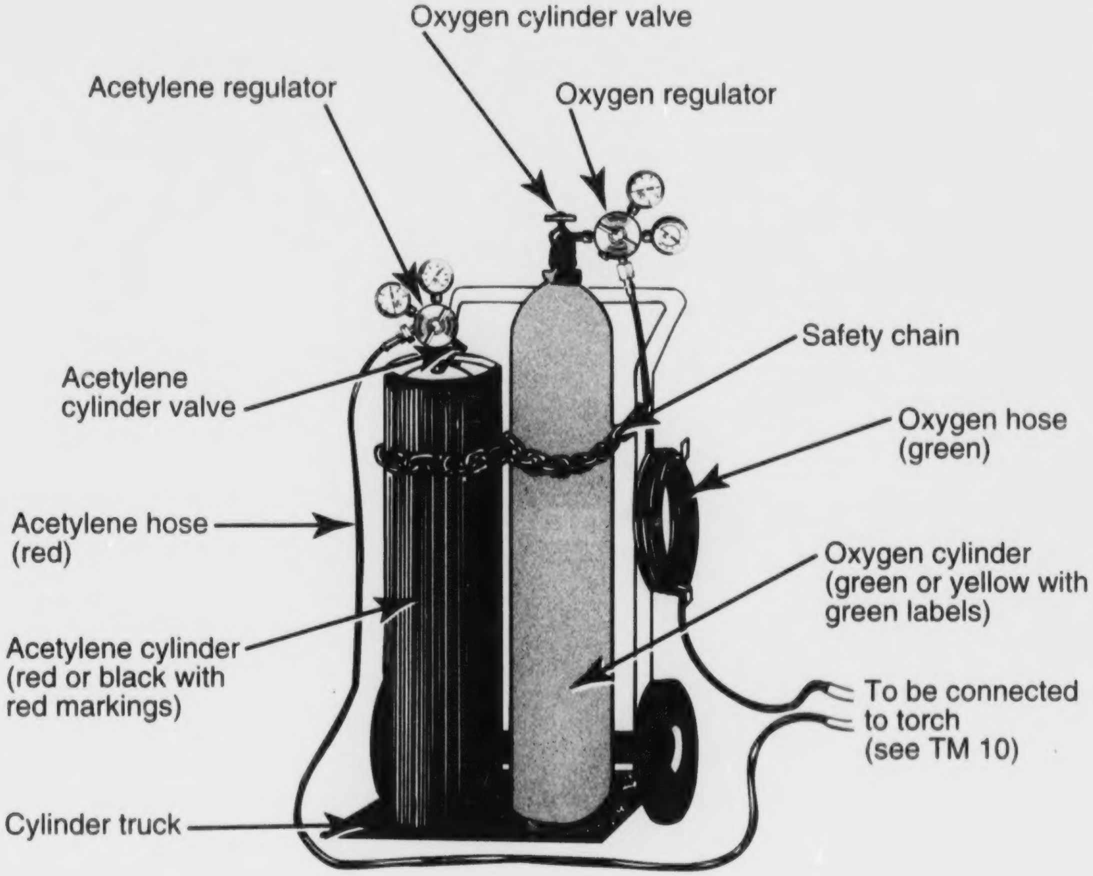


Overhead

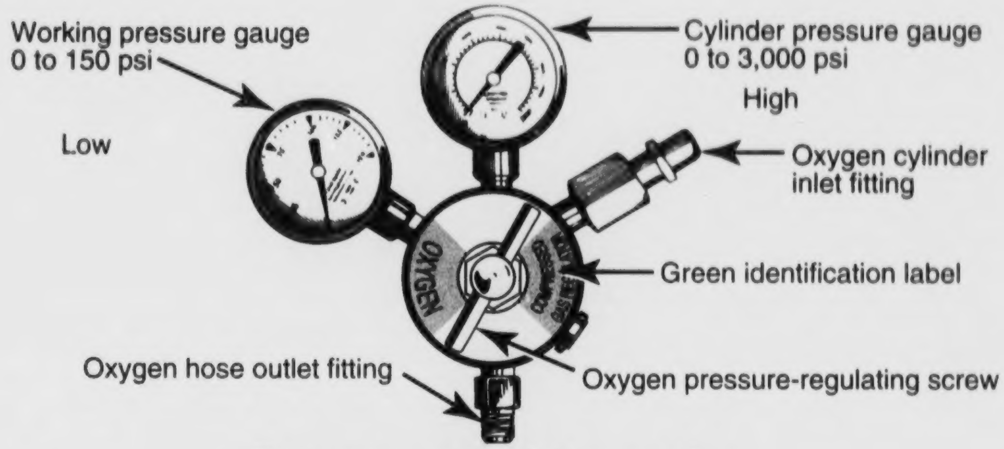


Horizontal

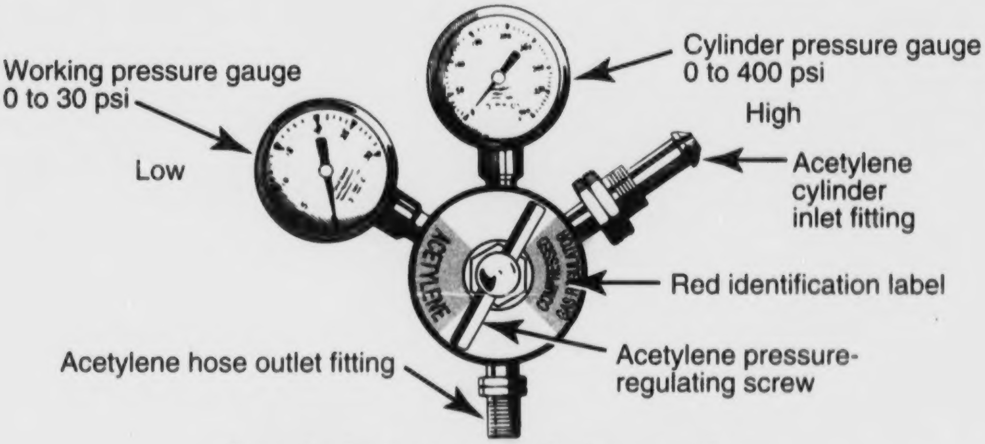
Parts of an Oxyacetylene Outfit


Oxygen cylinder valve
Acetylene regulator
Oxygen regulator
Safety chain
Acetylene cylinder valve
Oxygen hose (green)
Acetylene hose (red)
Oxygen cylinder (green or yellow with green labels)
Acetylene cylinder (red or black with red markings)
To be connected to torch (see TM 10)
Cylinder truck

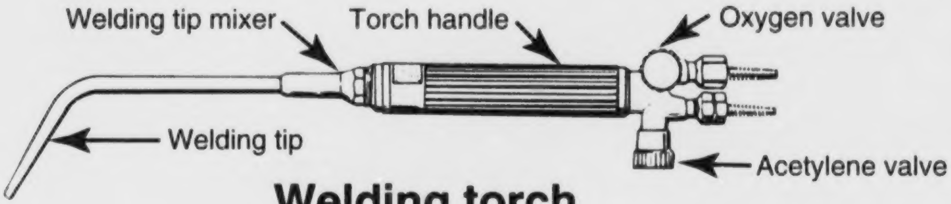
Parts of an Oxyacetylene Outfit
(Continued)


Working pressure gauge
0 to 150 psi
Low
Cylinder pressure gauge
0 to 3,000 psi
High
Oxygen cylinder inlet fitting
OXYGEN
COMPRESSED GAS
Green identification label
Oxygen hose outlet fitting
Oxygen pressure-regulating screw

Oxygen regulator valve

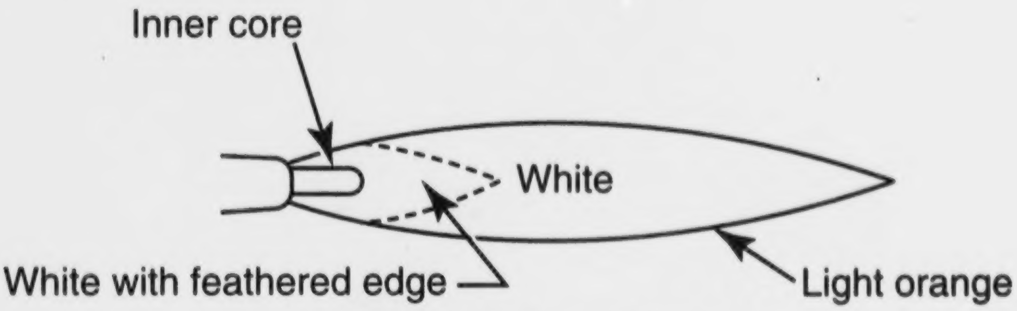

Working pressure gauge
0 to 30 psi
Low
Cylinder pressure gauge
0 to 400 psi
High
Acetylene cylinder inlet fitting
ACETYLENE
COMPRESSED GAS
Red identification label
Acetylene hose outlet fitting
Acetylene pressure-regulating screw

Acetylene regulator valve

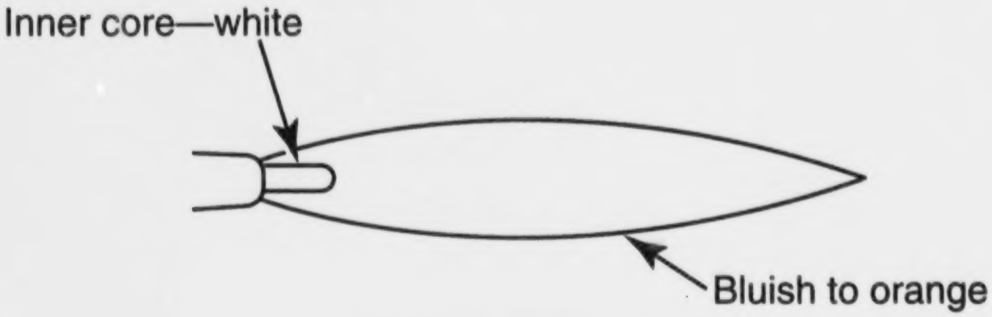

Welding tip mixer
Torch handle
Oxygen valve
Welding tip
Acetylene valve

Welding torch

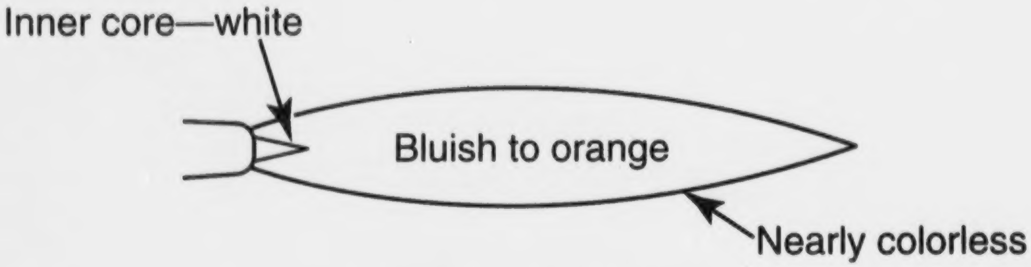
Types of Oxyacetylene Flames


Inner core
White
White with feathered edge
Light orange

Carburizing flame

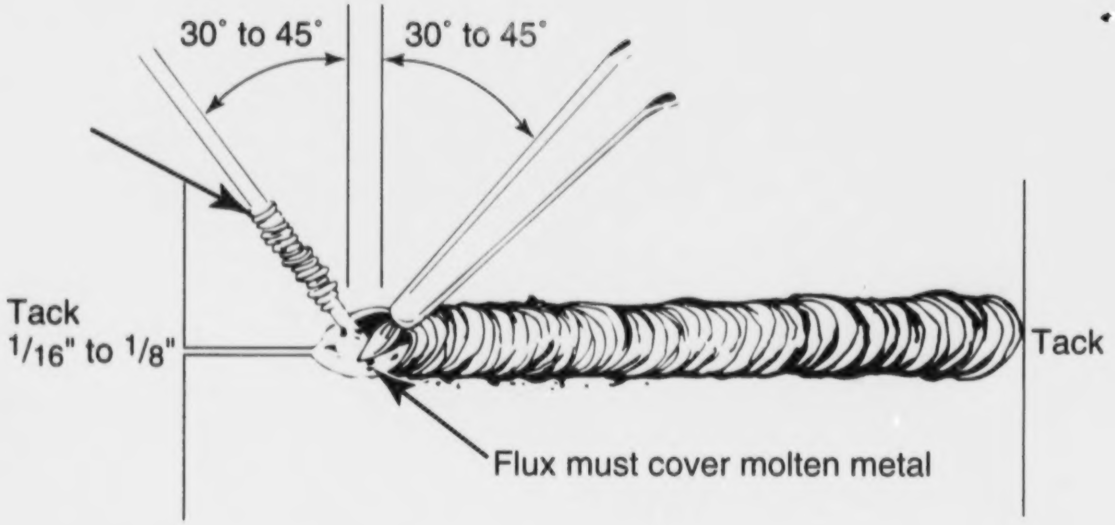

Inner core—white
Bluish to orange

Neutral flame

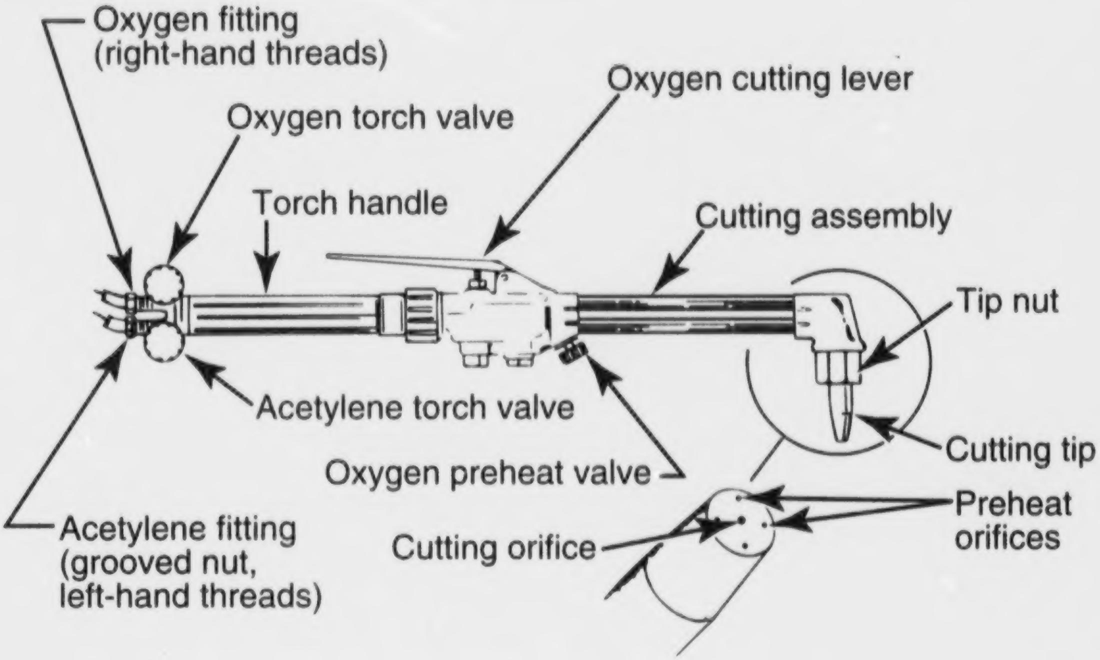

Inner core—white
Bluish to orange
Nearly colorless

Oxidizing flame

Oxyacetylene Braze Welded Butt Joint


30° to 45°
30° to 45°
Tack
1/16" to 1/8"
Tack
Flux must cover molten metal

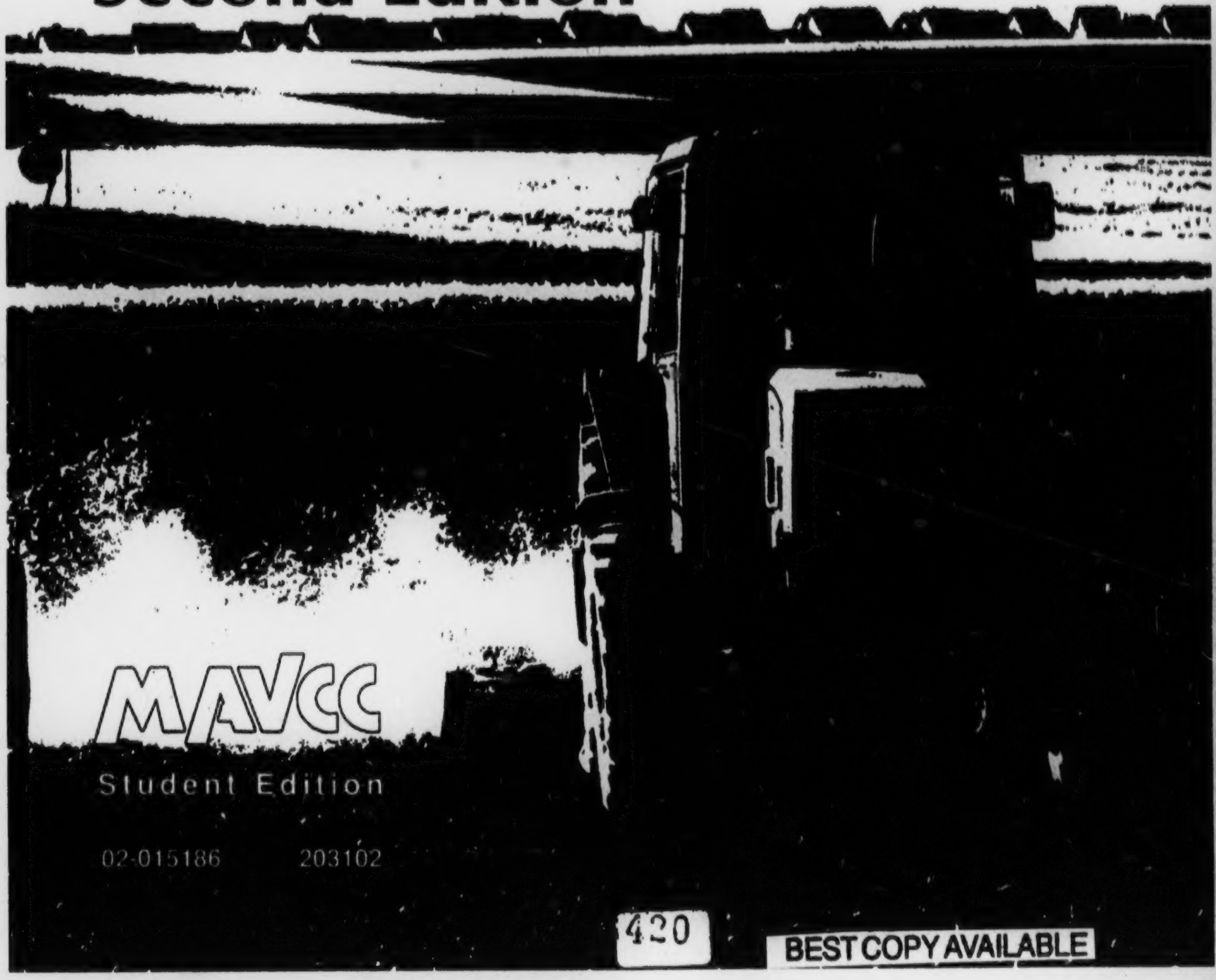
Parts of a Torch Key and Cutting Attachment



Oxygen fitting (right-hand threads)
Oxygen torch valve
Torch handle
Oxygen cutting lever
Cutting assembly
Tip nut
Acetylene torch valve
Cutting tip
Oxygen preheat valve
Preheat orifices
Acetylene fitting (grooved nut, left-hand threads)
Cutting orifice

Diesel Technology
Introduction

Second Edition



MAVCC

Student Edition

02-015186 203102

420

BEST COPY AVAILABLE

Diesel Technology: Introduction

Second Edition

Student Edition

Written by

John D. Joerschke
and
Lane C. Eichhorn

Edited by

Jane Huston

Developed by

Multistate Academic and Vocational Curriculum Consortium, Inc.
(MAVCC)
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

©2001

The Multistate Academic and Vocational Curriculum Consortium does not discriminate on the basis of race, creed, color, national origin, sex, age, religion, veteran status, or qualified handicap.

02-015186 203102

Table of Contents

Units of Instruction

Section A: Workplace Tools

Unit 1–A: Overview of Diesel-Powered Vehicles

Unit 2–A: Basic Tools and Equipment

Unit 3–A: Reference Materials

Unit 4–A: Measuring Instruments

Unit 5–A: Shop Operation

Section B: Common Materials

Unit 1–B: Mechanical Fasteners

Unit 2–B: Lines, Fittings, and Couplings

Unit 3–B: Seals and Bearings

Unit 4–B: Fluids and Lubricants

Section C: Basic Related Principles

Unit 1–C: Basic Electrical Principles

Unit 2–C: Basic Hydraulic Principles

Unit 3–C: Basic Welding and Cutting

Overview of Diesel-Powered Vehicles

Unit Contents

Student Components

Student Page

Objective Sheet 1A-3

Information Sheet 1A-5

Job Sheets

1—Identify Features for Assigned On-Road Vehicle 1A-23
2—Identify Features for Assigned Off-Road Vehicle 1A-25

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and discuss common on- and off-road diesel-powered vehicles and identify features for assigned vehicles. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to diesel-powered vehicles with their definitions.
2. Identify common diesel-powered vehicles.
3. List reasons for new vehicle designs.
4. Complete statements concerning the major functional areas of vehicles.
5. Match the major vehicle systems with their descriptions.
6. Distinguish among truck weights.
7. State gross vehicle weight ranges for on-road truck weight classifications.
8. Complete a chart of axle and drive wheel configurations.
9. Distinguish between basic truck cab designs.
10. Identify common types of trailers.
11. Match the parts of a trailer with their descriptions.
12. Identify types of tractor-trailer combinations.
13. Label truck dimensions.
14. Label agricultural tractor dimensions.
15. Distinguish among terms related to tractors.
16. Select true statements concerning characteristics of final drives.
17. Complete statements concerning characteristics of power takeoffs.
18. Complete statements concerning deck machinery.
19. Identify features for assigned on-road vehicle. (Job Sheet 1)
20. Identify features for assigned off-road vehicle. (Job Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Cab**—Driver-/passenger-carrying compartment

b. **Chassis**—Supporting frame of a vehicle; everything below the cab

c. **Circuit**—Circular path of a gas, liquid, or electrical power system

d. **Clearance (marker) lights**—Small amber and red lights attached to the cab and trailer to indicate overall clearance at night

e. **Component**—Member of a system; group of connected parts and/or assemblies often contained within a housing and designed to perform a specific but limited function within a system

f. **Drive component**—Part of the power/drive train that has engine power applied to it to make the vehicle move

Examples: Wheels/tires, tracks, rollers

g. **Fairing**—Member or structure whose primary function is to produce a smooth outline and to reduce drag

h. **Fifth wheel**—Coupling mechanism on the tractor that joins the truck-tractor to the trailer

i. **Friction**—Resistance to motion between two parts in contact

j. **Kingpin**—Pin on the trailer that connects to the tractor's fifth wheel

k. **Off-road vehicles**—Vehicles used for non-highway purposes such as construction or agricultural work

Note: Some off-road vehicles may use roads or highways to get to worksites, but their work is not done while on the highway.

l. **On-road vehicles**—Vehicles used on highways and intersections for the transportation of goods, raw materials, services, or people

m. **Pintle hitch**—Coupling mechanism that joins two trailers together

n. **Reflectors**—Glass or plastic prism lenses that reflect light

o. **Running gear**—Combined parts of a trailer that allow it to be pulled down the road

p. **Semitrailer**—Type of freight trailer that is supported on its forward end by the fifth wheel on the truck-tractor

q. **System**—Group of interconnected components or assemblies arranged in such a way that their separate functions work together to accomplish a broader function

r. **Vehicle design**—Plan of the elements of a vehicle, including their shape, the materials they are made of, and the way they fit together and function to achieve certain purposes

Objective 2

Common diesel-powered vehicles

a. On-road vehicles

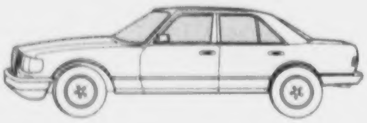


Figure 1—Automobile

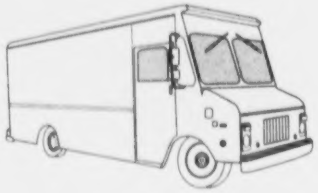


Figure 2—Van

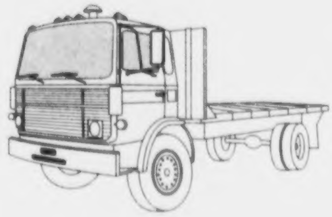


Figure 3—Straight truck (light-, medium or heavy-duty)

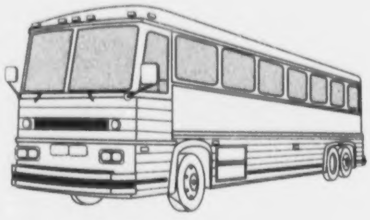


Figure 4—Bus

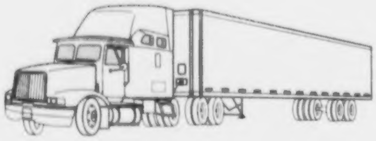


Figure 5—Truck-tractor with semitrailer connected

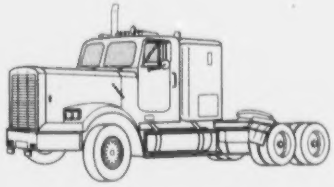
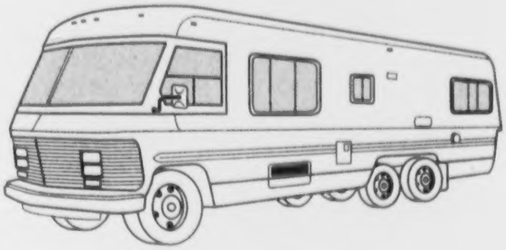


Figure 6—Truck-tractor without trailer (bobtail)

Figure 7—Recreational vehicle (RV) or motor home



b. Off-road agricultural vehicles

Figure 8—Tractor
(2-wheel drive)

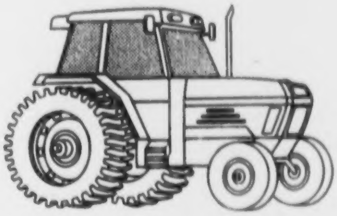


Figure 9—Tractor
(4-wheel drive)

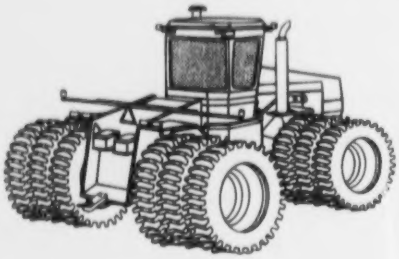


Figure 10—Tractor (track-type)

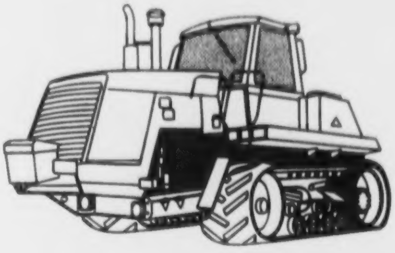
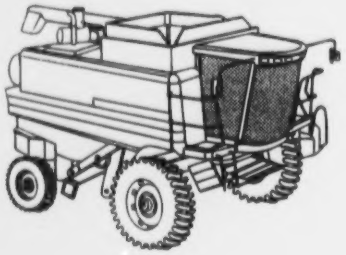


Figure 11—Combine/harvester



c. Off-road construction/industrial vehicles

Figure 12—Wheel-type tractor

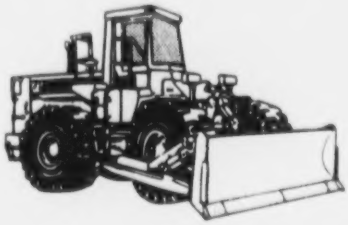


Figure 13—Track-type tractor (bulldozer)

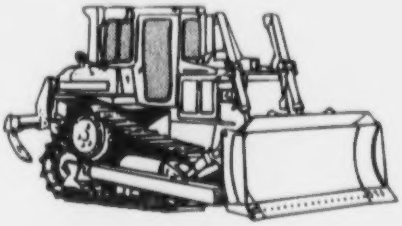


Figure 14—Wheel-type loader

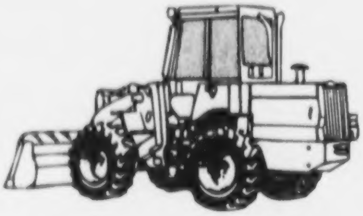
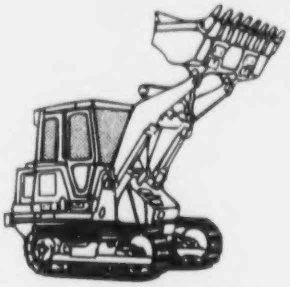


Figure 15—Track-type loader



Permission to reprint granted by Caterpillar Inc.

Figure 16—Backhoe loader

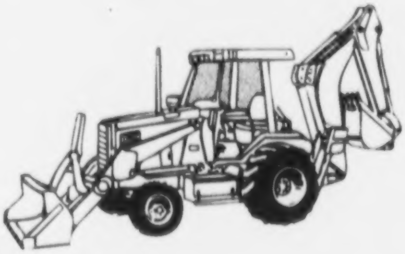


Figure 17—Motor grader

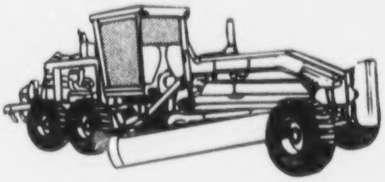


Figure 18—Off-road truck

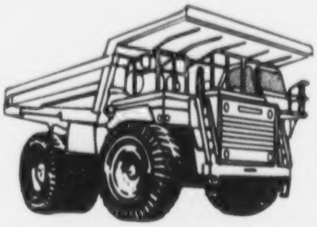


Figure 19—Asphalt paver

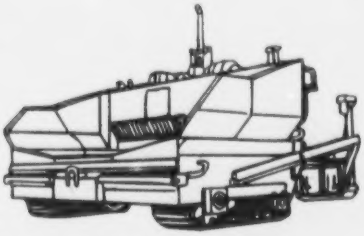


Figure 20—Crane

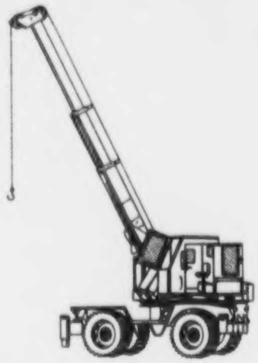
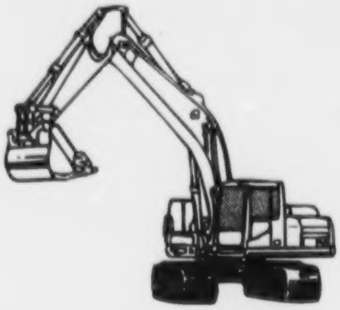


Figure 21—Excavator



Permission to reprint granted by Caterpillar Inc.

Note: In addition to those shown, there are many other diesel-powered vehicles designed for industry-specific jobs such as logging and mining, as well as many other types of equipment that use diesel engines such as generators, ships, and military equipment.

Objective 3

Reasons for new vehicle designs

Note: Design engineers are always trying to improve vehicle design for one or more of the following reasons:

a. For better fuel efficiency and lower costs

Examples: New aerodynamic designs reduce drag and result in lower fuel costs. New materials (lightweight metals and plastics) are used to reduce the weight of parts and overall fuel consumption.

b. For easier service

Example: Automatic drain valves reduce the need for frequently draining air tanks.

c. For longer life

Examples: New steel-belted radial tires last longer than old bias tires. New lubricants are designed to last longer before they must be changed.

d. To improve overall performance

Examples: New engine designs result in higher RPMs or compression rates. New materials are used for parts such as seals because they can withstand higher temperatures.

e. To improve driver comfort and safety

Examples: Sleeper cabs, air-suspended seats, seat belts, noise suppressants, climate control

f. To improve highway or environment safety

Examples: Fairings and flaps that reduce splash and spray on other vehicles; engine design changes to accommodate alternative fuels

Objective 4

Major functional areas of vehicles

a. **Body**—Part of the vehicle that carries the load

b. **Chassis**—Includes cab, frame, and suspension

c. **Power train**—Includes engine, engine brakes, and drive train

- **Engine**—Provides source of power to move vehicle; classified in several ways
  - Number of cylinders—Usually six or eight
  - Cylinder arrangement—V-type or in-line
  - Cooling system type—Liquid or air
  - Number of strokes to make a full cycle—Two-stroke or four-stroke

  Note: The piston and connecting rod will either make one movement up and one movement down (two strokes) the cylinder to complete the engine cycle sequence (intake, compression, power, and exhaust) or it will make two movements up and down (four strokes) to complete one cycle.

- **Engine brakes**—Use the engine's power to help slow the vehicle

- **Drive train**—Carries engine power to driving mechanism

  Note: The actual configuration of the drive train will vary, depending upon the type and size of the vehicle and the number of wheels or mechanisms being driven.

  - **Clutch** (for standard transmissions) or **torque converter** (for automatic transmissions)—Transmits power from engine to transmission
  - **Transmission**—Varies ratio of engine RPMs to drive shaft RPMs to maintain optimum power through vehicle's range of speed
  - **Retarder**—Slows drive line to help brake vehicle

- **Universal joint**—Connects components in drive line and enables them to operate at different angles
- **Drive shaft**—Transmits power between drive line components
- **Differential**—Transmits power from drive shaft to axle and permits drive wheels to turn at different speeds when going through a turn
- **Drive mechanism or component**—Receives power from drive train and propels vehicle

Examples: Wheel/tire, steel track, rubber track, roller

Objective 5

Major vehicle systems

a. Electrical systems

- Starting—Controls and powers electric motor used to start engine
- Charging system—Produces, controls, and monitors electrical current needed while vehicle is running; also recharges the storage batteries
- Chassis electrical system—Powers safety and warning devices, convenience accessories, and lights

b. Fuel system

- Functions
  - Provides fuel storage
  - Delivers fuel to engine
- Components
  - Fuel tank
  - Fuel lines
  - Fuel pump
  - Injectors

c. Engine lubrication system

- Reduces friction by providing lubrication around and between moving parts or contact points within engine
- Helps transfer heat to cool the engine
- Cleans engine by removing contaminants

d. Engine cooling system

- Circulates either air only or air and liquid to transfer heat of combustion and friction away from engine to prevent engine damage
- Common types of cooling systems
  - Liquid to liquid—Used primarily in marine and non-mobile applications
  - Air to liquid—Used primarily in mobile applications

e. Exhaust system

- Functions
  - Reduces noise caused by the combustion process within the engine
  - Directs harmful gases and heat away from engine and operator
- Components
  - Exhaust manifold—Connects cylinder outlets to single or dual pipes
  - Exhaust pipe—Conducts exhaust from manifold to muffler
  - Muffler—Decreases exhaust noises
  - Muffler extension or pipe—Carries gases farther past vehicle from muffler
  - Turbocharger—Returns heat energy from exhaust to engine to help power vehicle
  - Rain cap—Attached to top of muffler extension to keep rain out of exhaust system

Note: The exact configuration of an exhaust system will depend on the equipment's use. For instance, farm equipment and heavy-duty equipment often have exhaust systems that consist simply of a manifold, muffler, exhaust pipe, and rain cap or a manifold, turbocharger (which also acts as a muffler), exhaust pipe, and rain cap.

f. Steering system

- Allows driver to control direction of vehicle
- Transmits feel of operating surface to operator's hands

g. Suspension system

- Functions
  - Supports weight of vehicle
  - Absorbs shock that results from wheels or tracks hitting holes or bumps on operating surface
  - Allows cornering without extreme body roll
- Types of suspensions
  - Spring—Uses leaf-type spring assemblies
  - Equalizing beam—Used with tandem drives; employs either leaf springs or rubber cushions
  - Torsion bar—Torsion bars replace leaf springs
  - Air bag (or air spring)—Air springs replace leaf springs

h. Brake system

- Functions
  - Primary brake system allows operator to reduce speed of or stop moving vehicle
  - Parking brake holds vehicle stationary when parked
  - Emergency brake is activated if the primary air system fails
- Types of brake systems
  - Hydraulic brake systems—Transmit power to brakes through the use of hydraulic fluid, used on medium- and light-duty trucks
  - Air brake systems—Transmit power to brakes through the use of air; used on all heavy-duty trucks; can use single circuit or double circuit, but federal regulations have required all new vehicles to have double circuit systems since 1975

i. Heating and air conditioning system

- Heater—Heats outside air and circulates heated air into cab
- Air conditioner—Cools, dehumidifies, cleans, and delivers cool air to cab

j. Computer-control system—Electronically monitors and adjusts the operation of various systems and provides driver and service technician with information about those systems

Objective 6

Truck weights

a. **Tare weight**—Weight of the vehicle when empty

b. **Payload weight**—Weight of the commodity (payload) to be carried

c. **Gross vehicle weight (GVW)**—Weight of the vehicle when loaded

Tare weight + Payload weight = Gross Vehicle Weight (GVW)

Objective 7

On-road truck weight classifications by gross vehicle weight

Note: Different states have different weight requirements for licensure. Different engine emission controls are used depending on the vehicle's weight classification.

a. Light duty

- Class 1: up to 6,000 pounds
- Class 2: 6,001-10,000 pounds
- Class 3: 10,001-14,000 pounds

b. Medium-duty

- Class 4: 14,001-16,000 pounds
- Class 5: 16,001-19,500 pounds
- Class 6: 19,501-26,000 pounds

c. Heavy-duty

- Class 7: 26,001-33,000 pounds
- Class 8: 33,001 pounds and over

Objective 8

Axle and drive wheel configurations

Note: Truck classification by wheel number includes total number of wheels or sets of dual wheels and total number of driven wheels or sets of dual wheels.

Table 1—Truck Classification by Wheel Number

Motor Vehicle	Total Wheels	Driven Wheels	Total Axles	Drive Axles
4 x 2	4	2	2	1
4 x 4	4	4	2	2
6 x 2	6	2	3	1
6 x 4	6	4	3	2
6 x 6	6	6	3	3
8 x 4	8	4	4	2
8 x 8	8	8	4	4

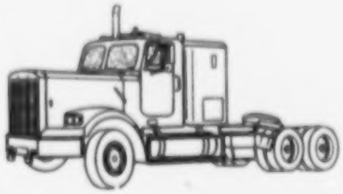
Objective 9

Basic truck cab designs

a. Conventional

- Cab sits behind the engine
- Offers driver a smoother ride and more protection because frame and engine are out front
- Hood is lifted for access to engine

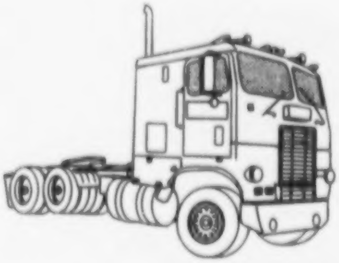
Figure 22



b. Cab-over-engine (COE) or cabover

- Cab is located directly over the engine
- Driver is seated as far forward as possible which provides greater visibility
- Shorter wheelbase allows for easier handling in traffic
- Entire cab must be tilted up and forward for access to engine

Figure 23

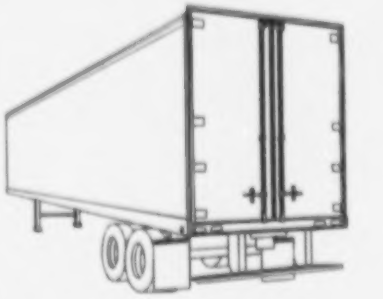


Objective 10

Common types of trailers (semi and full)

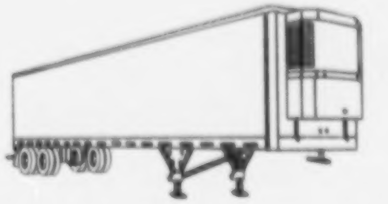
a. Van type–Dry freight

Figure 24



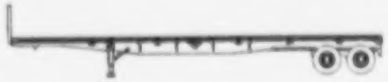
b. Van type–Refrigerated freight

Figure 25



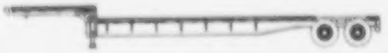
c. Flat bed

Figure 26



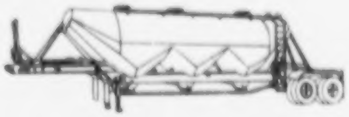
d. Flat bed, drop frame

Figure 27



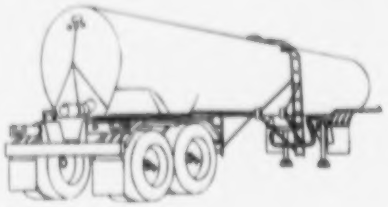
e. Tanker type–Dry bulk

Figure 28



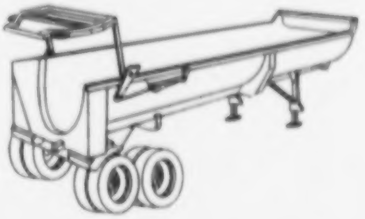
f. Tanker type–Liquid

Figure 29



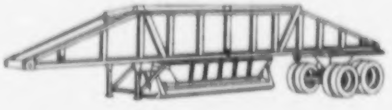
g. End dump type

Figure 30



h. Bottom dump type

Figure 31



Note: There are also many specialty trailers in use such as auto carrier, livestock, and logging trailers.

Objective 11

Parts of a trailer

a. Frame

- Inside or outside rails—Provide support for the load
- Kingpin—Locks into the tractor's fifth wheel to connect the trailer to the tractor
- Bulkhead—Wall on the front of the trailer that prevents cargo from sliding into tractor during stops
- Floor, walls (inside and outside), ceiling, and roof—Parts of the van's box shell that protect the cargo; commonly made of aluminum and reinforced, lightweight material such as fiberglass reinforced plastic (FRP)
- Doors—Allow access to the cargo; commonly swing type or roll-up type

b. Running gear

- Axles—Carry the weight of the cargo and transmit the load to the wheels
- Wheels—Transmit the weight of the cargo from the axles to the tires; provide rotary motion
- Tires—Transmit the weight of the cargo from the wheels to the road; provide traction
- Brakes—Slow and stop movement; consist of service brakes and emergency brakes
- Suspension system—Used to provide a smooth ride for driver and cargo
- Sliding tandems—Used to adjust the wheelbase of the trailer to help distribute trailer weight
- Landing gear—Holds up the front of the trailer when the trailer isn't hooked to the tractor

c. Lights and electrical wiring—Include clearance lights, turn signals, parking lights, rear lights, and brake lights. Wires that control these lights are contained in the "pigtail" at the front of the trailer.

d. Air system—Consists of two air couplings ("glad hands") that transmit air pressure from the tractor to the trailer brakes

- One glad hand provides air to the service brakes (pressurized only when brakes are applied)
- Other glad hand provides air to emergency brakes (pressurized at all times)

Information Sheet

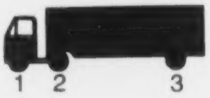
Objective 12

Types of tractor-trailer combinations

Note: Different states allow different total lengths for tractor-trailer units. The type of road (local/state highway vs. interstate) will also determine allowable combinations. The 27 ft. and 45 ft. trailers shown are most common. Other lengths such as 52-55 ft. are also available.

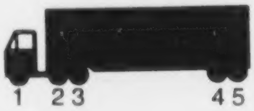
a. 3 axle tractor-semitrailer with 27 ft. trailer

Figure 32



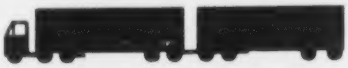
b. 5 axle tractor-semitrailer with 45 ft. trailer

Figure 33



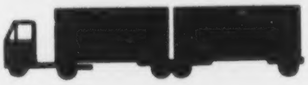
c. Turnpike double 45 ft. trailers

Figure 34



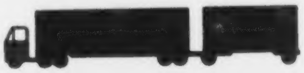
d. B-train double 27 ft. trailers

Figure 35



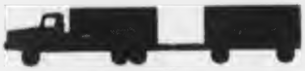
e. Rocky mountain double 45 ft & 27 ft.

Figure 36



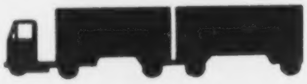
f. California truck and full trailer

Figure 37



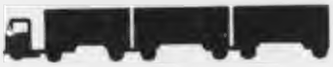
g. 65 ft. conventional double–27 ft. trailers

Figure 38



h. Triple 27 ft. trailers

Figure 39



Objective 13

Truck dimensions

a. BBC—Bumper to back of cab

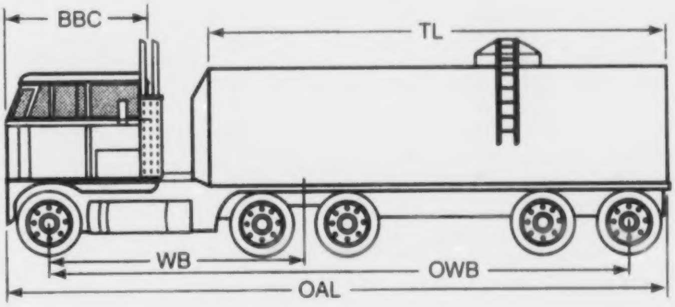
b. OAL—Overall length

c. OWB—Overall wheelbase

d. TL—Semitrailer length

e. WB—Wheelbase; distance between centerline of front and rear axle or tandem suspension

Figure 40



Objective 14

Agricultural tractor dimensions

a. DBC—Drawbar clearance

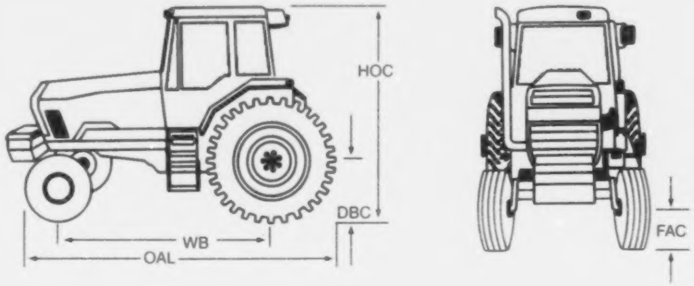
b. FAC—Front axle clearance

c. HOC—Height over cab

d. OAL—Overall length

e. WB—Wheelbase

Figure 41



Information Sheet

Objective 15

Terms related to tractors

a. **Deck machinery**—Equipment and machinery such as cranes, shovels, and loaders mounted on a turntable that allows it to rotate or swing

b. **Final drive**—Last gear in drive train to lower speed and raise torque before power reaches drive mechanism or drive sprocket

c. **Power takeoff (PTO)**—Power train component that powers auxiliary systems or implements

Objective 16

Characteristics of final drives

a. Locations of final drives

- Inboard—At differential end of axle shaft
- Outboard—At drive wheel end of axle shaft

b. Common types of final drive gears

- Pinion gear
- Planetary gear

Objective 17

Characteristics of power takeoffs

a. Standard gear arrangements for power takeoffs

- 540 rpm on 1 3/8″ shaft
- 1000 rpm on 1 3/8″ or 1 3/4″ shafts

b. Types of power takeoff controls

- Transmission driven—Operates only when clutch is engaged
- Independent—Starts and stops independently of transmission

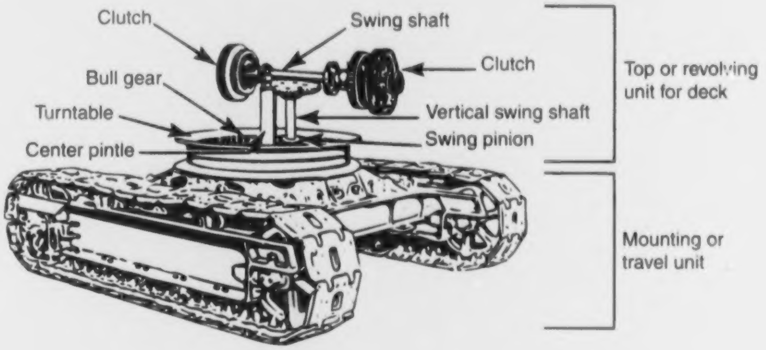
Objective 18

Deck machinery

a. Structural divisions of typical deck machinery (such as for excavator or crane)

- Top or revolving unit (superstructure)
- Mounting or travel unit—May be mounted on truck or self-propelled (wheel or tracks)
- Various attachments—Crane, bucket, etc.

Figure 42


Clutch
Swing shaft
Clutch
Bull gear
Turntable
Vertical swing shaft
Center pintle
Swing pinion
Top or revolving unit for deck
Mounting or travel unit

b. Power trains on typical deck machinery (such as an excavator)

- Hoist—Deck-mounted drums that control in/out and up/down movement of boom-attachment
- Swing—Upper unit supported by rollers or bolts on a turntable that rotates deck and swings boom in either direction
- Propel—Unit that provides means to walk or propel the vehicle

c. Boom structure for cranes

- A-frame—Steel structure on machinery deck with cross-bar slightly above cab roof
- Gantry—Steel structure on machinery deck projecting high above cab roof; supports boom cables on large equipment

Objective 19

Job Sheet 1—Identify Features for Assigned On-Road Vehicle

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Followed safety procedures during measuring and inspecting	______
• Obtained information from inspection of vehicle	______
• Handwriting neat and legible	______

Basic Skills

Reading Writing Critical Thinking Employability

Tools, Equipment, and Materials

- Safety glasses
- On-road vehicle, preferably some type of truck
- Tape measure—at least a 50 ft. length

Directions

Your instructor will provide you with access to an on-road diesel-powered vehicle. Inspect and study this vehicle to obtain the information requested. You will need a tape measure to find several dimensions requested. Observe all shop safety rules during inspection and measuring sequences.

Basic vehicle information

1. Engine information

   a. Number of cylinders ______________________

   b. Engine make and model ______________________

   c. Cylinder arrangement ______________________

   d. Type of cooling system ______________________

   e. Horsepower rating ______________________

2. Power train information
   - a. Make and type of transmission ________________
   - b. Type of final drive ________________
   - c. Axle make and drive wheel configuration ________________
   - d. Type of PTO ________________
3. General information
   - a. Make of vehicle and model ________________
   - b. Serial number ________________
   - c. Weight of vehicle: Tare ____________ GVW ____________
   - d. Type of cab ________________
   - e. Weight classification ________________

Vehicle dimensions

1. Tire size ________________
2. Wheelbase ________________
3. Overall length ________________
4. Bumper to back of cab ________________
5. Trailer length ________________
6. Overall wheelbase ________________

Evaluator's Comments: ________________

____

____

443

Objective 20

Job Sheet 2—Identify Features for Assigned Off-Road Vehicle

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety procedures during measuring and inspecting	______
• Obtained information from inspection of vehicle	______
• Handwriting neat and legible	______

Basic Skills

Reading Writing Critical Thinking Employability

Tools, Equipment, and Materials

- Safety glasses
- Off-road vehicle (agricultural or construction)
- Tape measure—at least 25 ft. length, preferably 50 ft.

Directions

Your instructor will provide you with access to an off-road diesel-powered vehicle. Inspect and study this vehicle to obtain the information requested. You will need a tape measure to find several dimensions requested. Observe all shop safety rules during inspection and measuring sequences.

Basic vehicle information

1. Engine information

   a. Number of cylinders ______________________

   b. Engine make and model ______________________

   c. Cylinder arrangement ______________________

   d. Type of cooling system ______________________

   e. Horsepower rating ______________________

2. Power train information
   a. Make and type of transmission ______________________
   b. Type of final drive ______________________
   c. Type of drive mechanism ______________________
   d. Type of PTO ______________________
3. General information
   a. Make of vehicle and model ______________________
   b. Serial number ______________________
   c. Weight of vehicle: Tare ____________ GVW ____________
   d. Bucket size ______________________
   e. Boom length and height ______________________
   f. Crane lifting capacity ______________________

Vehicle dimensions

1. Tire/track size ______________________
2. Wheel/track base ______________________
3. Overall length ______________________
4. Frame height/clearance ______________________

Evaluator's Comments: ______________________

____

____

Unit Contents

Student Components

Student Page

Objective Sheet 2A-3

Information Sheet 2A-5

Assignment Sheet

1—Use Tool Catalogs to Determine the Cost of a Quality Hand Tool Set 2A-31

Job Sheets

1—Dress a Grinding Wheel 2A-35
2—Sharpen a Twist Drill Bit 2A-37
3—Drill Hole With a Drill Press 2A-41
4—Sharpen a Cold Chisel 2A-43
5—Use a File 2A-47

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify all of the hand tools and general shop equipment specified by the ASE for diesel technicians and shops. The student should demonstrate these competencies by completing the assignment sheet and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic tools and equipment with their definitions.
2. Identify types of cutting tools.
3. Identify types of hammers.
4. Identify types of pliers.
5. Identify types of pullers.
6. Identify types of screwdrivers.
7. Identify types of wrenches.
8. Identify parts of a socket wrench set.
9. Identify basic power tools.
10. Identify basic shop equipment.
11. Identify other general shop tools and equipment.
12. Distinguish between correct and incorrect methods of using and maintaining basic hand tools.
13. Complete statements concerning safety guidelines to follow when using power tools and equipment.
14. Use tool catalogs to determine the cost of a quality hand tool set. (Assignment Sheet 1)
15. Dress a grinding wheel. (Job Sheet 1)
16. Sharpen a twist drill bit. (Job Sheet 2)
17. Drill hole with a drill press. (Job Sheet 3)
18. Sharpen a cold chisel. (Job Sheet 4)
19. Use a file. (Job Sheet 5)

Information Sheet

Objective 1

Terms and definitions

a. **Cutting tool**—Any edged tool used to remove material from a workpiece

b. **Equipment**—Large implements or machines used for various operations or tasks; may be mechanically, electrically, or electronically operated

Examples: Drill press, bench grinder

c. **Hammer**—Tool used to pound or strike a blow to another object

d. **Hand tool**—Small hand-held device operated only by manual effort for various tasks

Examples: Screwdriver, socket wrench, pliers

e. **Pliers**—Small pinching tool used to hold small parts, bend thin metal, or cut wire

f. **Power tool**—Hand-held device operated with electrical, hydraulic, or air assistance for various tasks

Examples: Drill, air impact wrench

g. **Puller**—Tool used to help disassemble or remove tight-fitting parts (such as pulleys and gears from shafts)

h. **Wrench**—Tool used to hold or turn bolts, nuts, or other parts

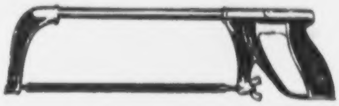
Objective 2

Types of cutting tools

Note: The following tools are basic hand tools used for cutting. Several machines may also be used for cutting. They will be covered later in this unit.

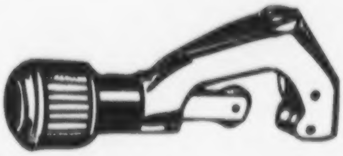
a. **Hacksaw**—Has fine-toothed blade held tightly in a frame; used for cutting metals and other hard materials

Figure 1



b. **Tubing cutter**—Used to cut soft metal tubes such as copper easily without damage

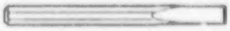
Figure 2



c. **Cold chisels**—Hardened, tempered, and specially shaped metal tools used to cut cold metal; come in a variety of shapes and sizes for specific purposes

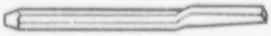
- Flat

Figure 3



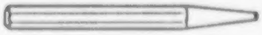
- Cape

Figure 4



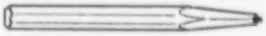
- Round nose

Figure 5



- Diamond point

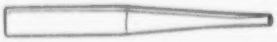
Figure 6



d. **Punches**—Used to make holes in metal or to mark workpieces so that drills can be started without moving about the work surface

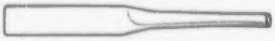
- Starting

Figure 7



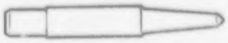
- Pin

Figure 8



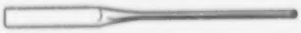
- Center

Figure 9



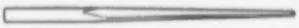
- Roll pin

Figure 10



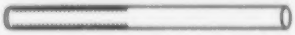
- Aligning

Figure 11



- Brass (drift)

Figure 12

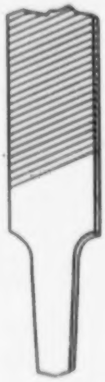


e. **Files**—Used to shape and smooth metal surfaces; have various teeth, shapes, and sizes

- Types of teeth

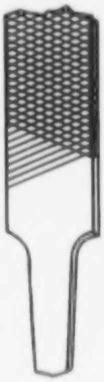
Single cut

Figure 13



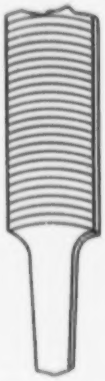
Double cut

Figure 14



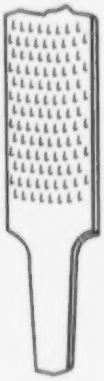
Curved tooth

Figure 15



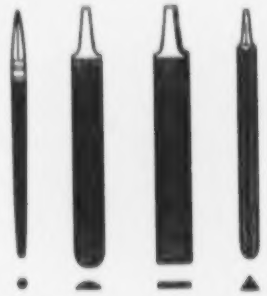
Rasp cut

Figure 16



- Common file shapes

Figure 17



— Round files are especially good for filing narrowly curved surfaces.

— Half-round files are used for filing broadly curved surfaces.

— Flat files work best on flat surfaces.

— Triangle files are good for filing flat surfaces in small openings.

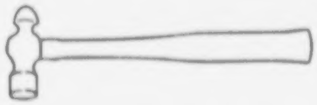
Objective 3

Types of hammers

a. **Hard-faced hammers**—Used to strike chisels and punches and to shape and straighten unhardened metal; usually made of steel

- Ball peen—Most commonly used

Figure 18



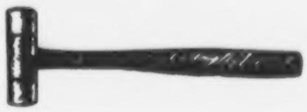
- Hand sledge—Used to strike objects that require (and can withstand) extra force

Figure 19

b. **Soft-faced hammers (or mallets)**—Used to strike surfaces that a hard-faced hammer might damage

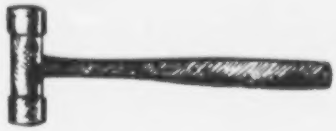
- Plastic

Figure 20



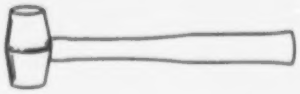
- Brass

Figure 21



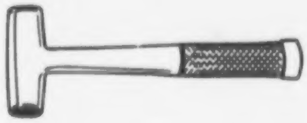
- Rubber

Figure 22



- Dead blow

Figure 23

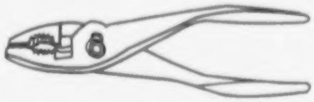


Objective 4

Types of pliers

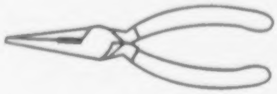
a. **Slip joint pliers**—Can be adjusted to hold different sized workpieces

Figure 24



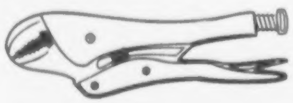
b. **Needle nose (long nosed) pliers**—Used for gripping very small objects in hard-to-reach places

Figure 25



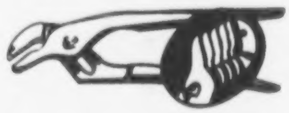
c. **Lock grip (Vise Grip®) pliers**—Have a clamping mechanism that fastens them tightly to the workpiece

Figure 26



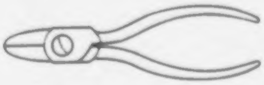
d. **Channel lock pliers**—Adjustable to a wide range of sizes

Figure 27



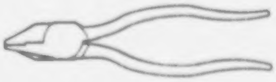
e. **Diagonal cutters**—Used to cut wire or bend thin, soft metal

Figure 28



f. **Side cutters**—Used to cut heavy wire and bend thin metals

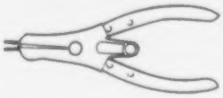
Figure 29



g. **Snap ring pliers**—Used to install and remove snap-ring fasteners

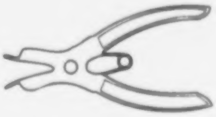
- External

  Figure 30



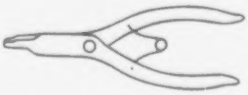
- Internal

  Figure 31



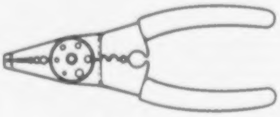
- Lock ring

  Figure 32



h. **Electrical pliers (crimper/stripper)**

Figure 33

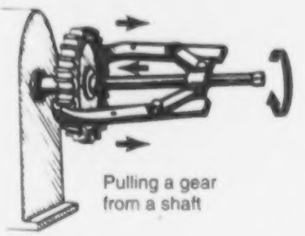


Objective 5

Types of pullers

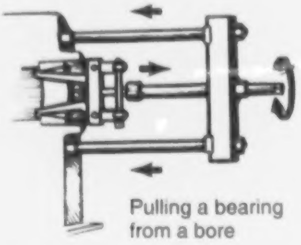
a. **External puller**—Used for tasks such as pulling gears and pulleys from shafts

Figure 34


Pulling a gear from a shaft

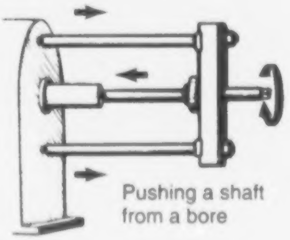
b. **Internal puller**—Used for tasks such as pulling a bearing from a bore

Figure 35


Pulling a bearing from a bore

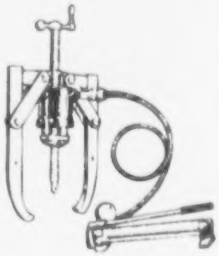
c. **Press type puller**—Used to press a shaft from a bore

Figure 36


Pushing a shaft from a bore

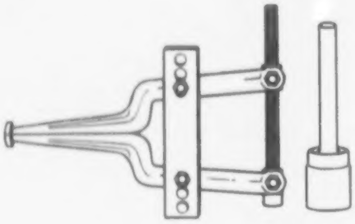
d. **Hydraulic puller**—Mechanically assists the pulling force with hydraulic power

Figure 37



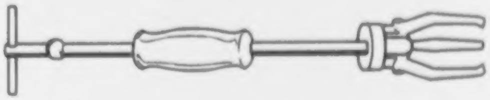
e. **Seal puller**—Used for removing seals

Figure 38



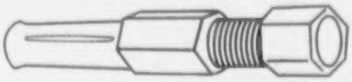
f. **Slide hammer puller**—Used to increase pulling force

Figure 39



g. **Blind hole puller**—Used for removing blind hole bearings, bushings, and sleeves

Figure 40



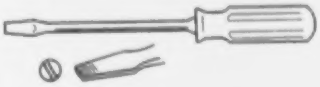
Objective 6

Types of screwdrivers

Note: Screwdrivers come in many sizes and a variety of head types. Common (flat blade) screwdrivers are used to turn screws with slotted heads. Other screw heads with recessed openings require specialty screwdrivers.

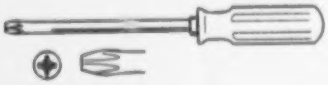
a. **Flat blade screwdriver**

Figure 41



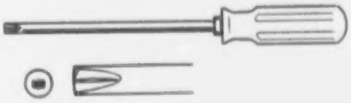
b. **Phillips® head screwdriver**

Figure 42



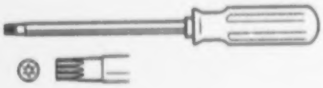
c. **Clutch head screwdriver**

Figure 43



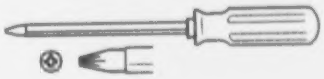
d. **Torx® screwdriver**

Figure 44



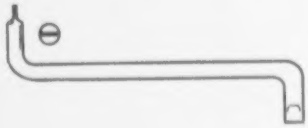
e. **Pozidriv® screwdriver**

Figure 45



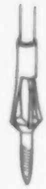
f. **Offset screwdriver**

Figure 46



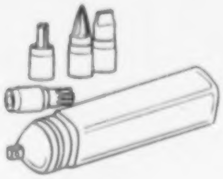
g. **Starting screwdriver**

Figure 47



h. **Impact driver**

Figure 48

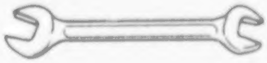


Objective 7

Types of wrenches

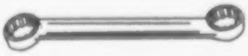
a. **Open end wrench**—Used on nuts or screws that can't be gripped with a box or socket wrench

Figure 49



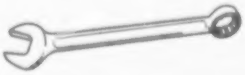
b. **Box wrench**—Close ends keep it from slipping off the workpiece

Figure 50



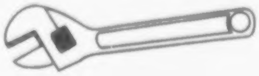
c. **Combination wrench**—Convenient because it has one open end and one box end of the same size

Figure 51



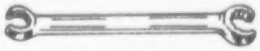
d. **Adjustable (Crescent®) wrench**—Moveable jaws fit wide range of nut and bolt sizes

Figure 52



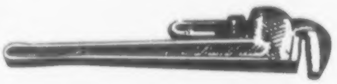
e. **Tubing (line) wrench**—Used to hold or turn tubing fittings that pliers or other wrenches might damage

Figure 53



f. **Pipe wrench**—Used to hold or turn pipes, shafts, and other cylindrical objects that are not easily damaged

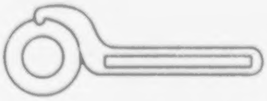
Figure 54



g. **Hook spanners**—Turn devices with corresponding holes or slots into which the hook fits; adjustable hook spanners can accommodate different sizes of fasteners

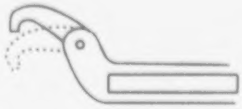
- Fixed

Figure 55



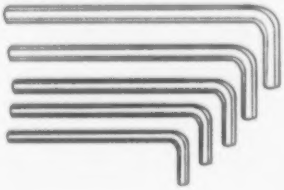
- Adjustable

Figure 56



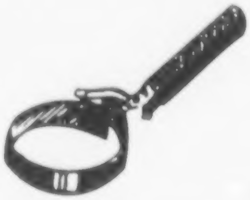
h. **Hex key (Allen) wrenches**—Fit threaded fasteners whose heads have hexagonal (hex) openings; come in sets of standard or metric sizes

Figure 57



i. **Filter wrench**—Used to remove cylindrical filters such as oil filters; available in several sizes

Figure 58



Note: A special type of wrench called a torque wrench will be covered in Unit 4 because it is considered a precision measuring instrument instead of a basic hand tool like other wrenches.

Objective 8

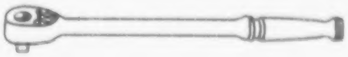
Parts of a socket wrench set

Note: Socket wrenches are special wrenches that consist of interchangeable handles and attachments which make them useful for a wide range of applications. Drives include 1/4″, 3/8″, 1/2″, 3/4″, and 1″.

a. **Handles**

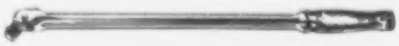
Ratchet handle—Used to turn a workpiece, backup the handle without turning the workpiece, and then turn the workpiece again without removing the wrench from the workpiece

Figure 59



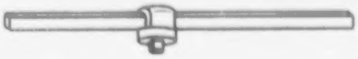
- Flex handle (breakover)—Adjusts to an infinite range of angles to turn hard-to-reach fasteners

  Figure 60



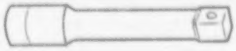
- Sliding "T" handle—Used to apply torque with both hands

  Figure 61



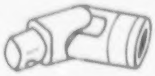
b. **Extensions**—Different lengths (short, medium, long) used to reach fasteners that are obstructed by other parts

Figure 62



c. **Universal joint**—Transfers torque through an angle to a difficult-to-reach fastener

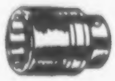
Figure 63



d. **Sockets**—Offer a strong and reliable method of turning threaded fasteners; several types are used; may be standard-rated or impact-rated

- Standard depth

  Figure 64

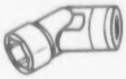


- Deep well

  Figure 65

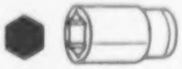
- Universal swivel/flex

  Figure 66



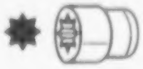
- Six point

Figure 67



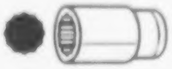
- Eight point

Figure 68



- Twelve point

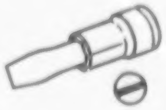
Figure 69



- Special purpose

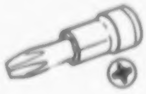
Standard

Figure 70



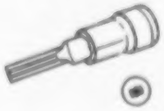
Phillips®

Figure 71



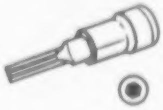
Clutch

Figure 72



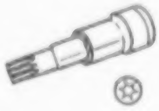
Hex head or Allen

Figure 73



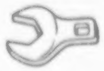
Torx®

Figure 74



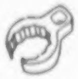
Crow foot

Figure 75



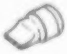
Crow foot line

Figure 76



Drag link

Figure 77

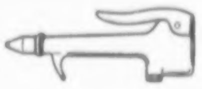


Objective 9

Basic power tools (hand held)

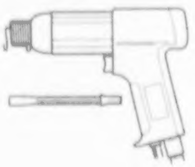
a. **Air blow gun**—Used for cleaning, drying, and blowing fluids out of lines

Figure 78



b. **Air hammer**—Used to deliver thousands of blows per minute; accepts many attachments for various purposes

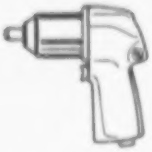
Figure 79



c. **Air wrenches**—Used to fasten and remove nuts and bolts; come in various sizes, size is determined by drive shank dimension

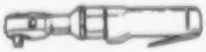
- Air impact

Figure 80



- Air ratchet

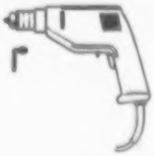
Figure 81



d. **Drill (variable-speed, reversible motor) with twist drill bits**—Used to bore holes in metal parts; reversing feature backs drill bit out of hole; may be air or electric powered

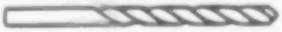
- Drill

Figure 82



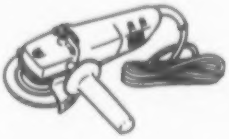
- Drill bit

Figure 83



e. **Sander/grinder**—Used to remove surface irregularities edges

Figure 84



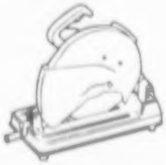
f. **Scraper**—Used to remove corrosion and leftover and rough gasket material from equipment parts

Figure 85

g. **Saws**—Used to make precision cuts on metal

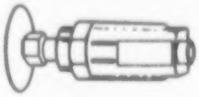
- Chop saw

Figure 86



- Cut off saw

Figure 87



Note: Welding equipment and battery chargers will be covered in later units.

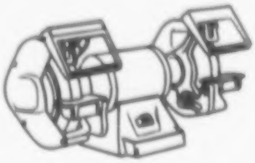
Information Sheet

Objective 10

Basic shop equipment

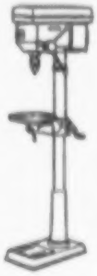
a. **Bench grinder**—Used to sharpen chisels, punches, and other tools

Figure 88



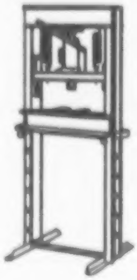
b. **Drill press**—Used to make precision holes in hard surfaces; drill is pressed into workpiece by electrical power

Figure 89



c. **Hydraulic press with adapter, 50 to 100 ton**—Used to remove bearings, pistons, wrist pins, cylinder sleeves, shafts, etc.

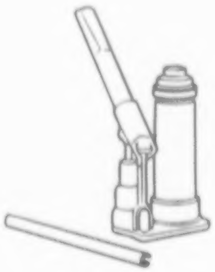
Figure 90



d. **Lifting equipment**—Used to lift, move, or hold heavy components

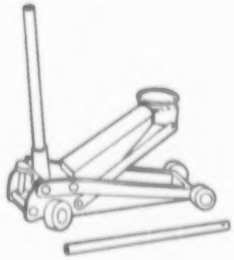
- Air bottle jack

Figure 91



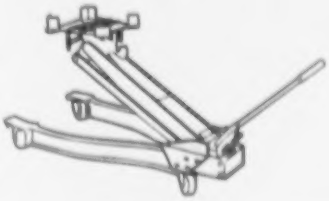
- Hydraulic service (floor) jack

Figure 92



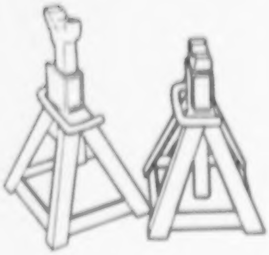
- Transmission jack

Figure 93



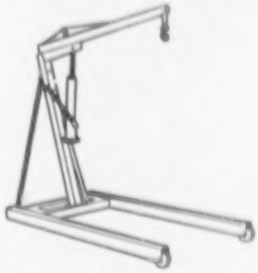
- Jack stands

Figure 94



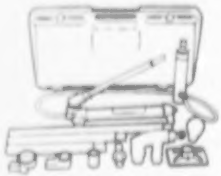
- Portable hydraulic crane

Figure 95



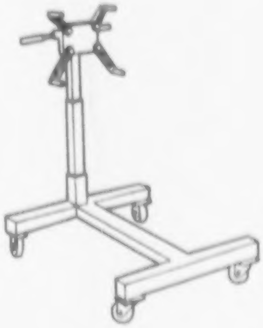
- Portable jack

Figure 96



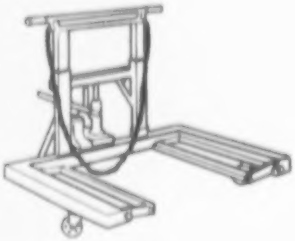
- Engine stand

Figure 97



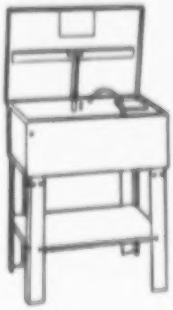
- Wheel dolly

Figure 98



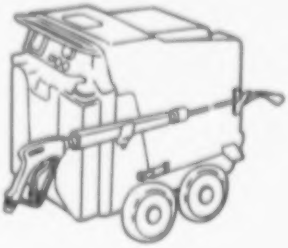
e. **Parts washer**—Used to hold cleaning solution and parts to be cleaned

Figure 99



f. **Steam pressure washer**—Used to remove dirt and grime from quipment

Figure 100



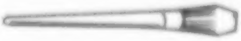
Objective 11

Other general shop tools and equipment

a. **Brushes**—Used to clean parts by removing rust, dirt, paint, and other materials

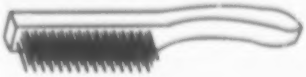
- Parts cleaning (for small, delicate parts)

Figure 101



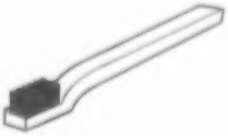
- Wire

Figure 102



- Brass

Figure 103

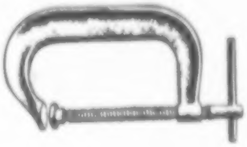


- Acid

Figure 104

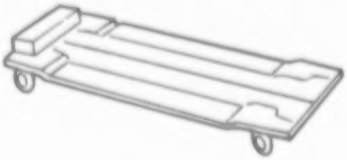
b. **C clamp**—Used to hold workpieces in place

Figure 105



c. **Creepers**—Used to roll under and back out from under vehicles

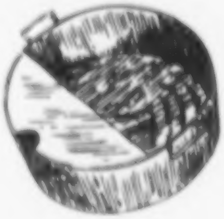
Figure 106



463

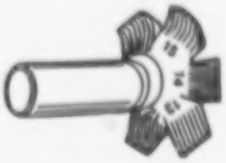
d. **Drain pan**—Used to collect old fluids when they are removed from engines, transmissions, radiators, and other systems

Figure 107



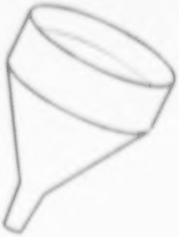
e. **Fin comb**—Used to check air conditioner and radiator fins

Figure 108



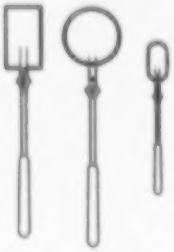
f. **Funnel** —Used to add fluids to or drain them from vehicle systems without spilling

Figure 109



g. **Inspection mirror**—Used when the view of a part is obstructed

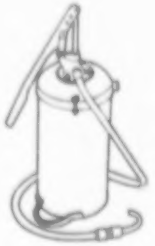
Figure 110



h. **Lubricating tools**—Used to apply lubricants to appropriate areas

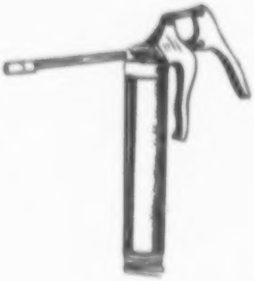
- Gear oil dispenser

Figure 111



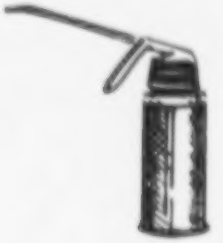
- Grease gun

Figure 112



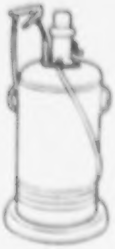
- Oil can

Figure 113



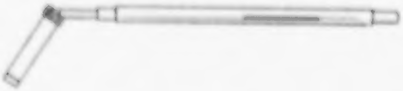
- Pneumatic grease gun

Figure 114



i. **Magnetic pickup tool**—Used to quickly gather small metal parts or fasteners

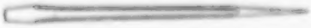
Figure 115



j. **Pry bars**—Used for leverage to move heavy or stubborn parts

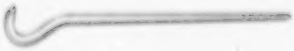
- Pinch

Figure 116



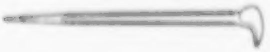
- Roll-head

Figure 117



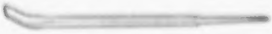
- Lady foot

Figure 118



- Line-up

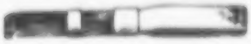
Figure 119



k. **Scrapers**—Used to remove grease and large amounts of dirt and corrosion from larger equipment parts

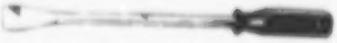
- Carbon scraper

Figure 120



- Gasket scraper

Figure 121



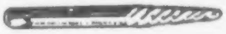
l. **Screw extractor (easy out)**—Used to remove seized bolts and screws

- Square

Figure 122

- Spiral flute

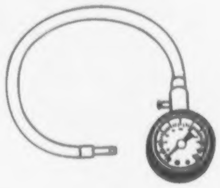
Figure 123



m. **Tire tools**—Used to check tire specifications and for other purposes when working with tires

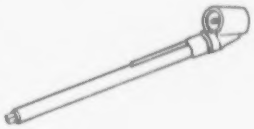
- Tire pressure gauge—dial type

Figure 124



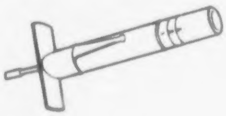
- Tire pressure gauge-pencil type

Figure 125



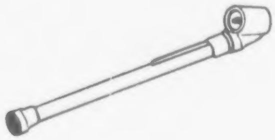
- Tire tread depth gauge

Figure 126



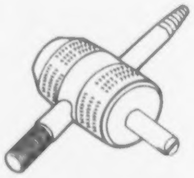
- Tire chuck—truck

Figure 127



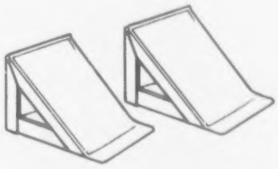
- Tire valve core removers

Figure 128



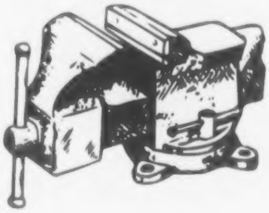
- Tire chocks

Figure 129



n. **Vise**—Used to hold workpieces securely, making work safer and easier

Figure 130



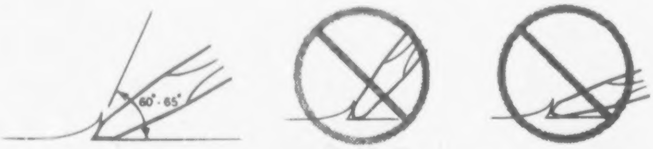
Objective 12

Methods of using and maintaining basic hand tools

a. Chisels

- Use chisels that are properly sharpened. **Never** use a dull or improperly ground cold chisel.
- Dress dull cutting edges to the original shape and 60°-65° angle.

Figure 131



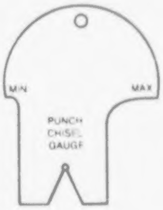
Correct angle 60°- 65°

Angle is too large

Angle is too small

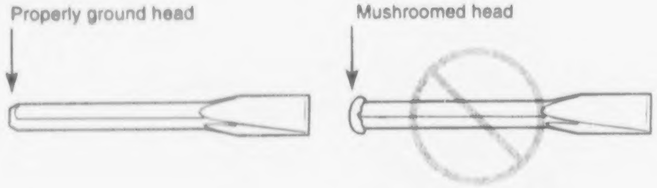
- Use a punch and chisel gauge to make sure the tip has been dressed to the correct angle.

Figure 132



- Use a chisel with a properly ground head. **Never** use a cold chisel with a mushroomed head.

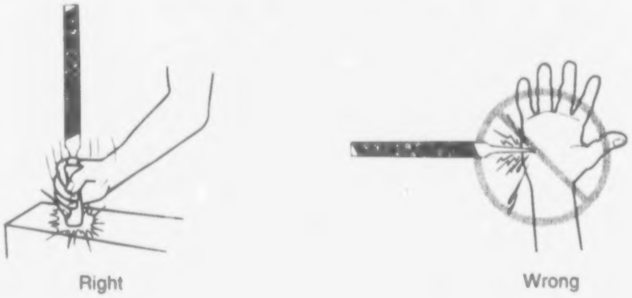
Figure 133


Properly ground head
Mushroomed head

b. Files

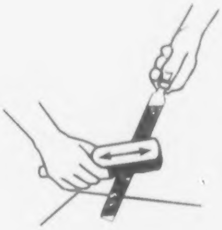
- Always use a handle on a file. Tighten the handle by tapping it on a solid surface or screw on where appropriate.

Figure 134


Right
Wrong

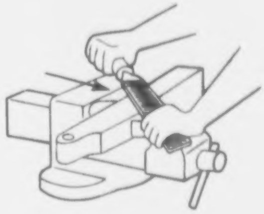
- Clean a file by using a file card.

Figure 135



- Secure material being filed in a vise. Hold file firmly in both hands while filing. Use long even strokes and apply pressure only on the forward stroke of the file.

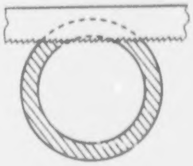
Figure 136



c. Hacksaw

- Make sure that teeth point away from handle and that blade it tightly stretched. Use sufficient pressure on the forward stroke and use the full length of the blade on each stroke.

Figure 137

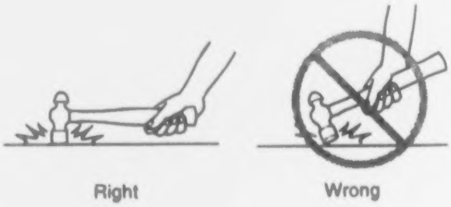


- Select a blade with the correct number of teeth per inch for the material being cut. Three teeth should always be in contact with the material being cut. Blades are available in medium (18 tooth), fine (24 tooth), and very fine (32 tooth).

d. Hammer

- Hit a surface with the full striking face of the hammer. **Never** hit a surface with the edge of the hammer's striking face.

Figure 138

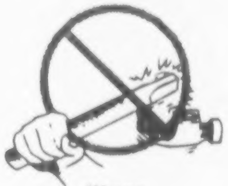


Right

Wrong

- **Never** use a hammer with a lose handle.

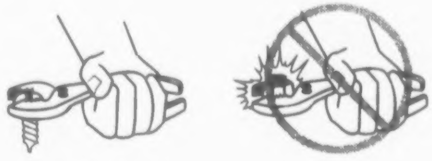
Figure 139



Wrong

e. Pliers—Pliers may be used to remove damaged screws, but **never** use pliers to loosen nuts and bolts.

Figure 140



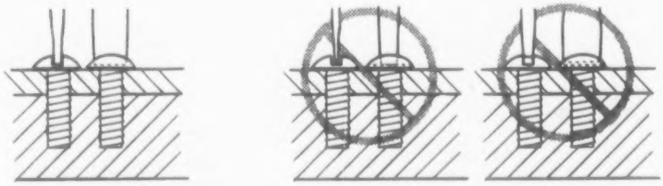
Right

Wrong

f. Screwdriver

- Use a screwdriver with a blade that fills the screw slot. **Never** use a screwdriver with a blade that is too wide, too narrow, too thick, or too thin for the screw slot.

Figure 141



Blade approximately same width as screw head and as thick as screw slot

Blade too narrow and too thin

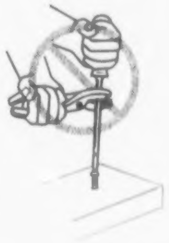
Blade too wide and too thick

Right

Wrong

- **Never** use pliers on the shank of a screwdriver to loosen a screw.

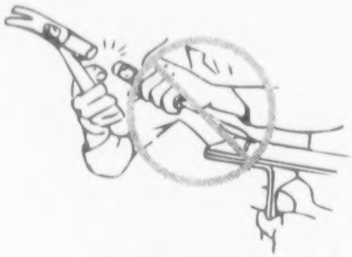
Figure 142



Wrong

- **Never** use a screwdriver as a cold chisel.

Figure 143

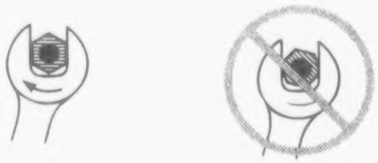


Wrong

g. Wrench

- Use a wrench that is the exact fit for the nut or bolt you are working with. **Never** use a wrench that is larger than the nut or bolt.

Figure 144

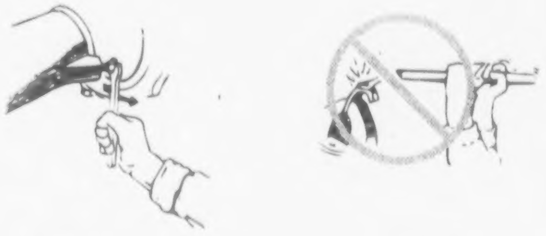


Right

Wrong

- When using a wrench, pull the handle toward you whenever possible. **Never** use a bar or pipe to extend a wrench handle. The extra force may bend or break the wrench.

Figure 145

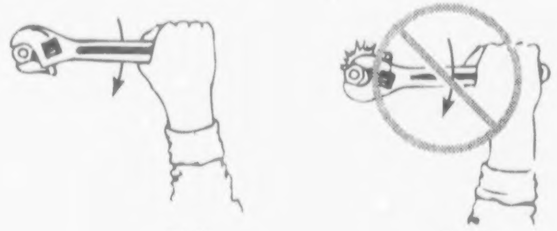


Right

Wrong

- When using an adjustable wrench, exert force against the large jaw of the wrench (so that the large jaw is opposite the direction of force). **Never** exert force against the small jaw.

Figure 146

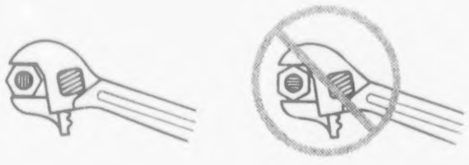


Right

Wrong

- When using an adjustable wrench, adjust the wrench to fit the flat surfaces of the nut. **Never** pull on a wrench before it has been tightened.

Figure 147



Right

Wrong

Information Sheet

Objective 13

Safety guidelines to follow when using power tools and equipment

a. Always wear personal protective equipment when using power tools and equipment. Safety glasses/goggles protect you from flying particles and ear plugs/muffs protect you from loud noises that can lead to hearing loss.

b. Operate power tools and equipment only after receiving training on how to use them properly and safely.

c. Remove rings and other jewelry when operating power tools and equipment.

d. Secure long hair and loose clothing such as ties, scarves, or wide sleeves when working around power tools and equipment.

e. Obey all safety rules and operating instructions provided by the equipment manufacturer, plus any additional ones used by your shop.

f. Keep guards and safety devices in place on all equipment.

g. Tag and report to the supervisor/instructor any defective tools or equipment.

h. Turn off power equipment when not in use.

i. **Never** use compressed air to clean yourself or clothing. Do **not** direct compressed air toward another person.

j. Use tools only for their intended purposes and applications.

Examples: Do not use a sander as a grinder.

Objective 14

Assignment Sheet 1—Use Tool Catalogs to Determine the Cost of a Quality Hand Tool Set

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Followed directions	______
• Priced every item listed	______
• Added correctly	______
• Selected best Grade A quality tools for the price	______
• Filled out ordering forms correctly	______

Basic Skills

Reading Mathematics Critical Thinking Employability

Introduction

As a diesel technician, you will be expected to own your own set of hand tools when you go to work. The following table lists the hand tools you will be expected to own. When you select the tools you will use during your career, tool quality should be your main concern. The tools you select should be at least Grade A quality. The initial price of Grade A quality tools can be expensive, but in the long run they will pay for themselves many times over in the greater number of years of service they will provide if you care for them properly.

Materials List

- Tool catalogs, price lists, and order forms
- Calculator

Directions

Your instructor will provide you with several tool catalogs, current price lists for each catalog, and an ordering blank for each catalog. Your goals in this exercise are (1) to learn to use tool catalogs and (2) to do some comparison shopping and learn how to get the best quality tool set for your money.

Using the table and the tool catalogs your instructor provides, find at least three price quotes for each tool listed in the table on the following pages, record those prices, and then circle the best price for each tool.

Next, on the table, add the individual tool prices to determine the tool price for your hand tool set. Finally, fill out an order form for each tool company you have indentified as the best company from which to purchase your tools. Check catalogs for order forms and copy as needed.

Turn in your completed table and order forms by your instructor.

Assignment Sheet 1

Tool Description	Cost Company 1	Cost Company 2	Cost Company 3
1. Chisels			
a. Cape 5/16"			
b. Flat 5/8", 3/4"			
2. Files and handles			
a. 4", 10", and 12" double cut, flat			
b. 6" and 12" single cut, flat			
c. 6" and 12" half round			
3. Hacksaw			
4. Hammers			
a. Ball peen — 16 oz.			
b. Soft face, plastic			
5. Inspection mirror			
6. Magnetic pickup tool			
7. Pliers			
a. Slip joint			
b. Needle nose			
c. Lock grip			
d. Channel lock			
e. Side cutter or diagonal cutter			
f. Electrical (crimper/stripper)			
8. Punches			
a. Pin, 3/16" - 3/8"			
b. Starting, 3/16" - 3/8"			
c. Brass (drift)			
d. Center			
9. Scraper, 1" wide or larger			
10. Screwdrivers			
a. Flat (slotted)			
• 1"			
• 6"			
• 9"			
• 12"			
• Offset			
b. Phillips®			
• 1" — #1, #2			
• 6" — #1, #2			
• 12" — #3			

Tool Description	Cost Company 1	Cost Company 2	Cost Company 3
c. Pozidriv® offset — 6", 12"			
d. Torx® set — t-15, t-20, t-25, t-30			
e. Impact driver set			
11. Socket wrench sets			
a. ¼" drive			
• 3/16" - ⅝" sockets, US standard depth			
• 3/16" - ⅝" sockets, US deep			
• 4mm - 14mm sockets, US metric standard depth			
• 4mm - 14mm sockets, US metric deep			
• Short, medium, and long extensions			
• Ratchet handle			
• Universal joint			
b. ⅜" drive			
• ¼" - ⅞" sockets, US standard depth (12-point)			
• ¼" - ⅞" sockets, US deep (6-point)			
• 8mm - 19mm metric sockets, standard depth (6-point)			
• 8mm - 19mm metric sockets, deep (6-point)			
• Breaker bar			
• Short, medium, and long extensions			
• Ratchet handle			
• Universal joint			
c. ½" drive			
• ⅜" - 1⅛" sockets, shallow (impact or chrome)			
• 7/16" - 1⅛" sockets, deep (impact or chrome)			
• 10mm - 32mm sockets, shallow (impact or chrome)			
• 10mm - 32mm sockets, deep (impact or chrome)			
• Breaker bar			
• Short, medium, and long extensions			
• Ratchet handle			

Assignment Sheet 1

Tool Description	Cost Company 1	Cost Company 2	Cost Company 3
• Universal joint			
12. Wire brush			
13. Wrench set, combination			
a. Standard			
• ⅜" - 1"			
• Up to 1¼" (optional)			
b. Metric			
• 6mm - 19mm			
• Up to 24mm (optional)			
14. Wrench set, flare nut			
a. Standard ⅜" - ¾"			
b. Metric 7mm - 19mm			
15. Wrench set, hex key (Allen)			
a. Standard			
• .050 - ⅜"			
• 1/16" - ½" (optional)			
b. Metric (2mm - 12mm)			
TOTAL			

Objective 15

Job Sheet 1—Dress a Grinding Wheel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Selected proper dressing tool	______
• Dressed the grinder wheel until edges were square with sides	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Employability Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety goggles
- Grinding wheel on grinder
- Dressing tool

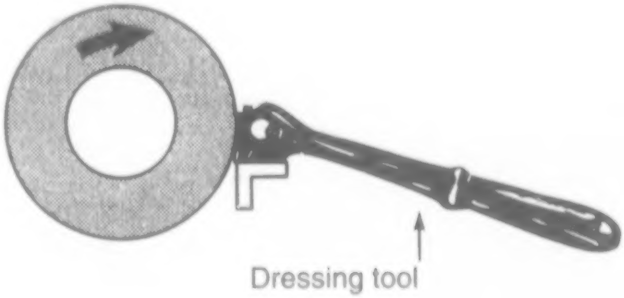
Procedure

Caution: Follow all shop safety procedures.

☐ 1. Select the proper dressing tool.

☐ 2. Set the dressing tool on the grinder tool rest, and press it firmly against the wheel.

Figure 1



☐ 3. Dress the grinder wheel with the tool until the edges are square with the sides.

☐ 4. Readjust tool rest to no more than 1/8" from grinding wheel.

Evaluator's Comments: ____________________

Objective 16

Job Sheet 2—Sharpen a Twist Drill Bit

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Held drill against grinding wheel correctly	______
• Kept drill cool	______
• Did not force drill too fast	______
• Sharpened drill at correct angle	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Mathematics Critical Thinking Employability Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

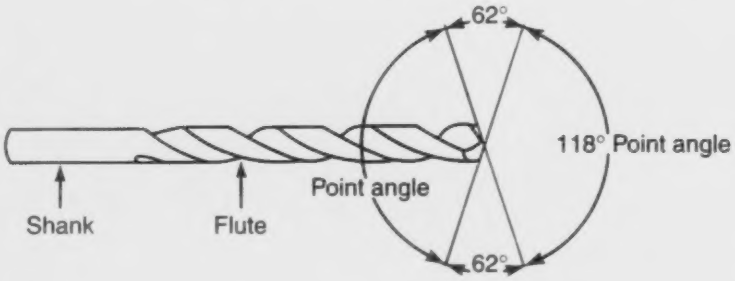
- Safety goggles
- Grinder
- Twist drill and bits
- Drill gauge
- Container of water

Procedure

Caution: Follow all shop safety procedures.

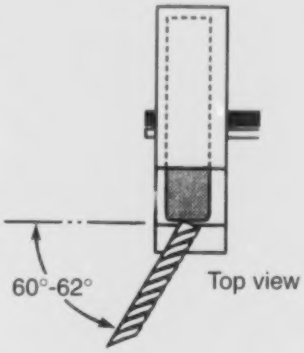
☐ 1. Use a drill gauge to check the point angle of the drill bit. A common drill bit has a point angle of 118°.

Figure 1



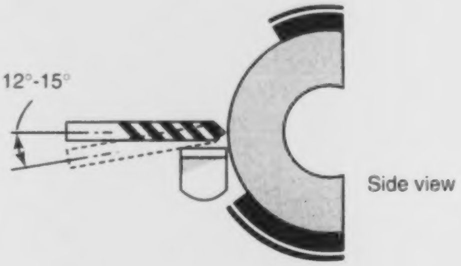
☐ 2. Place the drill point against the grinding wheel at a 60°-62° angle for a common drill bit.

Figure 2



☐ 3. Using both hands, lower the shank, and raise the bit cutting point against the wheel. Do not force drill bit too fast.

Figure 3



☐ 4. Rotate the bit in a clockwise manner while grinding.

☐ 5. Grind both lips in the same manner.

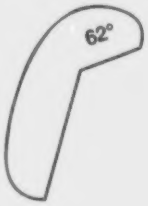
☐ 6. Dip the point in water frequently to keep it cool.

> Caution: Watch for coloration on tip of drill; if tip starts to turn blue, it is too hot.

481

☐ 7. Check accuracy of sharpening with drill bit gauge. Regrind as necessary to obtain correct angle.

Figure 4



Evaluator's Comments: ______________________________

____

____

Objective 17

Job Sheet 3—Drill Hole With a Drill Press

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Measured hole accurately	______
• Positioned the workpiece on the drill properly	______
• Selected proper drill speed	______
• Drilled hole in correct place	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Critical Thinking Employability Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

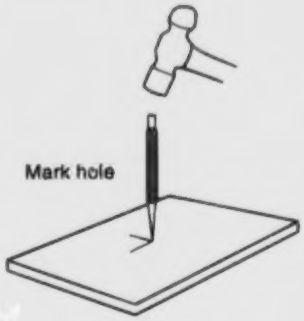
- Safety goggles
- Small piece of flat metal
- Drill press
- Center punch
- Hammer
- Wooden block
- Cutting oil
- Clamp
- Measuring tool

Procedure

Caution: Follow all shop safety procedures.

☐ 1. Measure and mark the hole with a center punch.

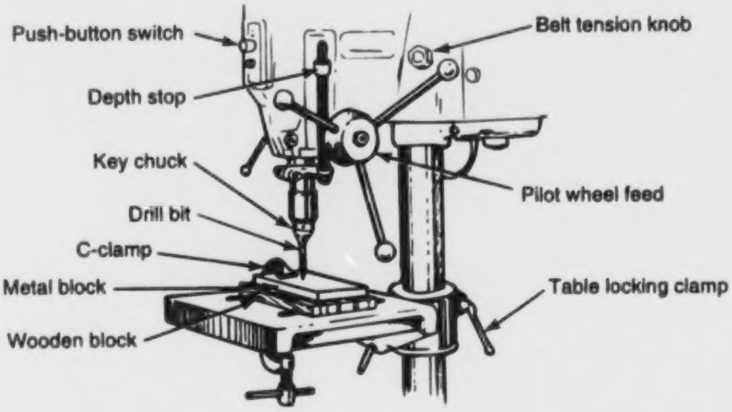
Figure 1



☐ 2. Place the metal on a wooden block.

☐ 3. Clamp the metal being drilled securely to prevent it from spinning.

Figure 2


Push-button switch
Belt tension knob
Depth stop
Key chuck
Pilot wheel feed
Drill bit
C-clamp
Metal block
Table locking clamp
Wooden block

☐ 4. Select the correct drilling speed for the material. Feed the bit down to the metal and start drilling.

☐ 5. Raise the bit to see if you are drilling in the proper place.

☐ 6. Continue drilling, applying cutting oil to the drill bit two or three inches above the work.

Evaluator's Comments: ______________________________

____

____

Objective 18

Job Sheet 4—Sharpen a Cold Chisel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Held chisel against grinding wheel correctly	______
• Kept chisel cool	______
• Ground both sides of cutting edge to form sixty-degree angle	______
• Ground mushroomed head into correct shape if needed	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Critical Thinking Employability Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

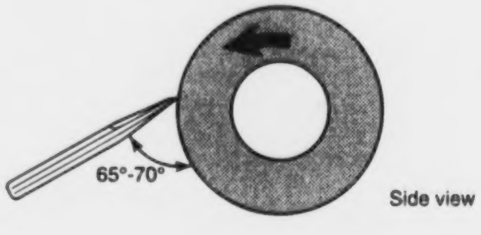
- Safety goggles
- Cold chisel
- Grinder with safety shields
- Chisel gauge
- Container of water

Procedure

Caution: Follow all shop safety procedures.

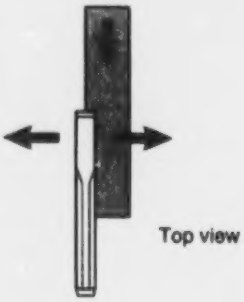
☐ 1. Hold the chisel at a 65°-70° angle with the handle pointing out. Check tool rest for proper adjustment.

Figure 1



☐ 2. Move the point from side to side across the grinding wheel.

Figure 2

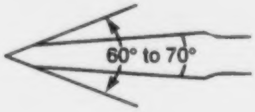


☐ 3. Dip the point in water frequently to keep it cool.

Note: Do not allow tip to turn blue; it will be too hot. If whole tip becomes dark blue, the temper (toughness) is removed by the heating effect. This leaves the tip hard and brittle. Discard any chisels ruined by excessive heat.

☐ 4. Grind both sides of the cutting edge in the same manner.

Figure 3

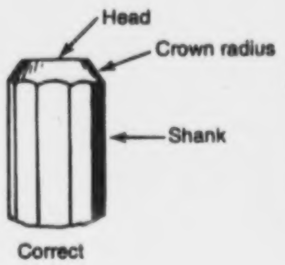


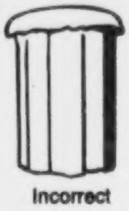
☐ 5. Check accuracy of tip with a chisel gauge. Regrind as necessary to obtain correct angle.

☐ 6. If the head has become mushroomed, it should be ground back into shape.

Note: The head should be square with the shank, and the crown radius should taper away from the head.

Figure 4


Head
Crown radius
Shank
Correct



Evaluator's Comments: ______________________________

____

____

437

Objective 19

Job Sheet 5—Use a File

Name ______________________ Attempt Number ______

Date ______________________ Overall Rating ______

Evaluation Criteria	**Rating**
• Followed safety rules throughout procedure	______
• Placed workpiece in vise correctly	______
• Used file properly	______
• Filed workpiece to desired size/smoothness	______
• Demonstrated quality workmanship throughout	______

Basic Skills

Reading Critical Thinking Employability Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety goggles
- File with handle
- Vise
- Stock to be filed
- Wire brush or file card

Procedure

Caution: Follow all shop safety procedures.

☐ 1. Secure material to be filed in a vise.

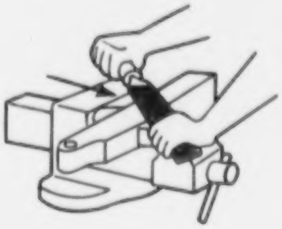
Note: Material being worked on should not extend very far above or beyond the jaws of the vise.

☐ 2. Hold file firmly in both hands while filing.

☐ 3. Use long, even strokes with the file.

☐ 4. Apply pressure only on the forward stroke of the file.

Figure 1



Note: Light pressure is usually sufficient when the right file is being used for the job.

☐ 5. Lift file up slightly on the backstroke to prevent damage to file.

☐ 6. Clean small particles of metal from file with a wire brush or file card.

Evaluator's Comments: ______________________________

____

____

Unit Contents

Student Components

Student Page

Objective Sheet 3A-3

Information Sheet 3A-5

Assignment Sheets

1—Interpret Drawings Used in Diesel Equipment Reference Materials 3A-15
2—Interpret Graphs Used in Diesel Equipment Reference Materials 3A-19
3—Interpret Diagrams Used in Diesel Equipment Reference Materials 3A-23
4—Interpret Tables Used in Diesel Equipment Reference Materials 3A-27
5—Use Reference Materials to Answer Specific Questions 3A-33

400

Objective Sheet

Unit Objective

After completing this unit, the student should be able to use diesel equipment reference materials. The student should demonstrate these competencies by completing the assignment sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to diesel equipment reference descriptions with their definitions.
2. Match types of reference materials with their descriptions.
3. Distinguish between types of illustrations used in reference materials.
4. Identify types of graphs used in reference materials.
5. Identify types of diagrams used in reference materials.
6. Identify the parts of a reference table.
7. Match types of tables used in reference materials with their descriptions.
8. Interpret drawings used in diesel equipment reference materials. (Assignment Sheet 1)
9. Interpret graphs used in diesel equipment reference materials. (Assignment Sheet 2)
10. Interpret diagrams used in diesel equipment refrence materials. (Assignment Sheet 3)
11. Interpret tables used in diesel equipment reference materials. (Assignment Sheet 4)
12. Use reference materials to answer specific questions. (Assignment Sheet 5)

Information Sheet

Objective 1

Terms and definitions

a. **After-market vendor**—Company that supplies parts or components used to service a vehicle or piece of equipment

Examples: Dana, Rockwell, Felpro, AC Delco, Gates, Cummins, FederalMogul, Midland-Grau

b. **Diagram**—Special type of illustration that explains rather than represents; generally used to show flow of a substance, energy through a system, or logical order of a process

c. **Graph**—Special type of illustration used to show the relationship between two or more quantities (or variables)

Note: Graphs are convenient methods for showing changing characteristics as they relate to each other.

d. **Illustrations**—Drawings, photographs, diagrams, and other graphics used to clarify information contained in reference materials

e. **Make of equipment**—Identification of equipment according to its manufacturer and associated brand names

f. **Model number**—Numerical designation used to identify an equipment design, usually coded to indicate specifications

g. **On-line reference**—Computerized database system that allows parts and service personnel to access parts and service information (parts diagrams and numbers, service bulletins and procedures, recall notices, etc.) directly from an OEM or aftermarket source in real-time (live)

Note: In-house CD-ROM information retrieval systems are also available.

h. **Original equipment manufacturer (OEM)**—Company that manufactures and sells the final end product such as tractor-trailer, construction equipment, or agricultural equipment

Examples: Kenworth, Peterbilt, Caterpillar, John Deere, Case-IH, Navistar

i. **Reference materials**—Books, pamphlets, videotapes, CD-ROMs, on-line information, microfilms, microfiche, and other materials used by diesel service technicians as sources of information in servicing equipment

j. **Specifications**—Measurements and features that apply to a specific type and model of equipment

Examples: Measurements—Fluid quantities, clearances, tolerances
Features—Type of ignition system, transmission, steering

Objective 2

Types of reference materials and their descriptions

Note: Although the materials described in this section are described as print materials, reference information is available in a number of formats including microfiche, microfilm, compact disc (CD), databases, and other media.

a. **Owner's/driver's manual**

- Book or booklet developed by an equipment manufacturer for a particular piece of equipment
- Designed to provide the user with general operating and maintenance instructions and specifications

b. **OEM service manual**

- Book or books developed by a diesel equipment manufacturer for a particular piece of equipment
- May consist of one large bound book or may be a series of books, each covering one system, such as transmission, cooling system, engine, steering system, etc.
- Designed to provide service personnel with detailed instructions and specifications for troubleshooting, maintaining, and repairing system components

c. **After-market service manual**

- Book developed by an agency other than the original equipment manufacturer for a variety of engines and/or equipment
- Designed to provide general instructions for various products, generally from more than one manufacturer
- Volumes usually cover particular types and classes of equipment such as medium-duty trucks, heavy-duty trucks, heavy equipment, agricultural equipment, etc.
- Editions usually cover several years of models and may overlap.

  Example: The second edition of a manual might cover model years 1987-1993, while the third edition covers the years 1987-1994.

- Manual might also cover only one particular system such as electrical, transmission, brakes, etc.

d. **Diagnostic or troubleshooting manual**—Book or books issued by OEM/parts manufacturer or after-market vendor to provide specific testing/troubleshooting procedures

e. **Maintenance manual**—Handbook that gives detailed information on daily and periodic inspections, specific maintenance procedures, change intervals, and lubrication charts

f. **Parts manual**

- Book used to identify equipment parts, generally through the use of parts drawings and lists
- May be published by the OEM or by companies that specialize in the manufacture of replacement parts
- May list the parts produced by one company or may list parts from several companies that can be used as substitutes for each other; this latter use is sometimes referred to as an interchange manual

g. **Service products/tools catalog**—Catalog of specially-designed products or tools needed to perform particular equipment maintenance and repair tasks

h. **Service bulletin**—Notice issued by an OEM on a frequent or regular basis to update or clarify service manuals or to alert service personnel to a special or new procedure

i. **Parts bulletin**—Notice issued by an OEM or parts manufacturer on a frequent or regular basis to update parts manuals, to introduce new parts, or to provide supplementary information about parts

j. **Government publications**—Books, pamphlets, and bulletins outlining federal and state safety and environmental procedures and requirements

Objective 3

Basic types of illustrations used in reference materials

a. **Photographs**

- Taken by a camera to show an actual part or a step in a procedure
- May include part numbers or letters as callouts to simplify the illustration

b. **Drawings**

- Used to convey more detailed and more complex information than a photograph can illustrate
- May be pictorial (picture-like), sectional (cutaways), or detailed (closeups)

Information Sheet

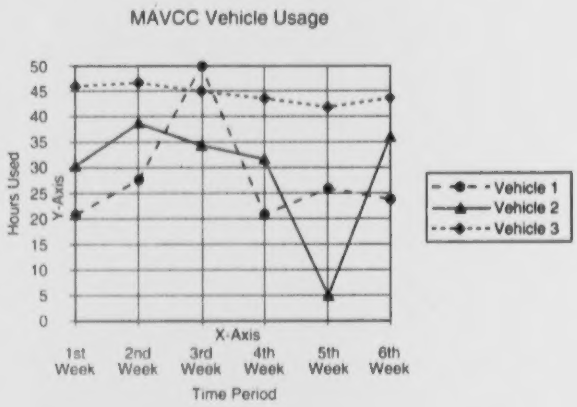
Objective 4

Types of graphs used in reference materials

a. **Line graph**

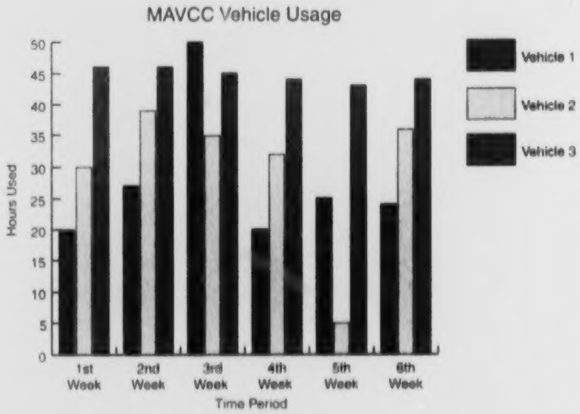
- Shows the values of variables at specific points
- Usually consists of an x-axis (horizontal line) and a y-axis (vertical line) marked off in units of measurement
- As measurements are taken, they are plotted on the graph as points. These plot points can then be connected with plot lines.

Figure 1—Example of line graph



b. **Bar graph**—Uses bars to show measurements from the x- or y-axis (instead of plot points and plot lines)

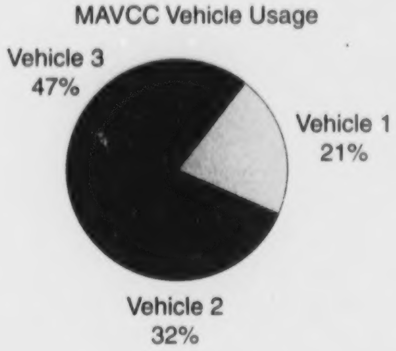
Figure 2—Example of bar graph



Note: Figures 1 and 2 present the same information in two different graph formats.

c. **Circle graph** (or pie chart)—Generally used to show percentages of variables that make up a whole quantity

Figure 3—Example of circle graph (or pie chart)

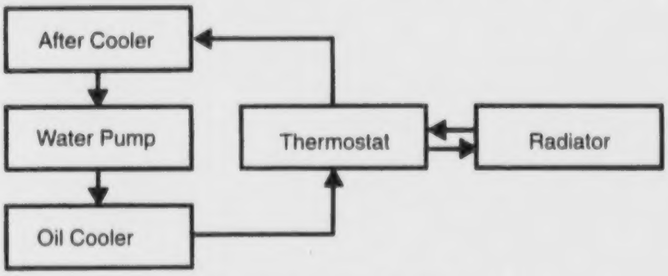


Objective 5

Types of diagrams used in reference manuals

a. **Block diagrams**—Use boxes with the components' names to represent the elements in a system and their connections or flow

Figure 4—Example of a block diagram

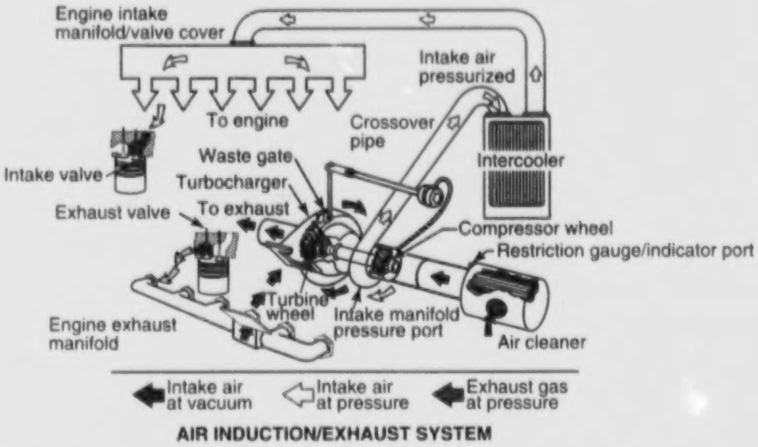

After Cooler
Water Pump
Oil Cooler
Thermostat
Radiator

Diesel Engine Cooling System

b. **Pictorial diagrams**

- Use drawings to represent the components in the system and their connections or flow
- May either label the components or leave it to the user to identify them

Figure 5—Example of a pictorial diagram

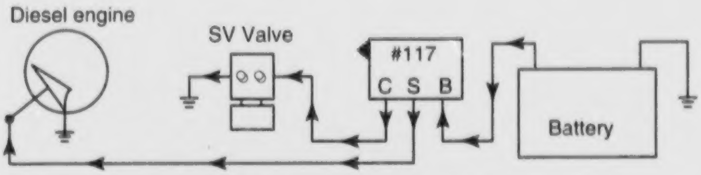

Engine intake manifold/valve cover
Intake air pressurized
To engine
Crossover pipe
Intercooler
Intake valve
Waste gate
Turbocharger
To exhaust
Exhaust valve
Compressor wheel
Restriction gauge/indicator port
Turbine wheel
Intake manifold pressure port
Engine exhaust manifold
Air cleaner
Intake air at vacuum
Intake air at pressure
Exhaust gas at pressure
AIR INDUCTION/EXHAUST SYSTEM

Reprinted with the permission of NAVISTAR International Transportation Corp.

c. **Schematic diagrams**

- Represent a system's components and connections with standardized symbols
- Often used to illustrate electrical circuits
- May or may not label the components

Figure 6—Example of a schematic diagram


Diesel engine
SV Valve
#117
C S B
Battery

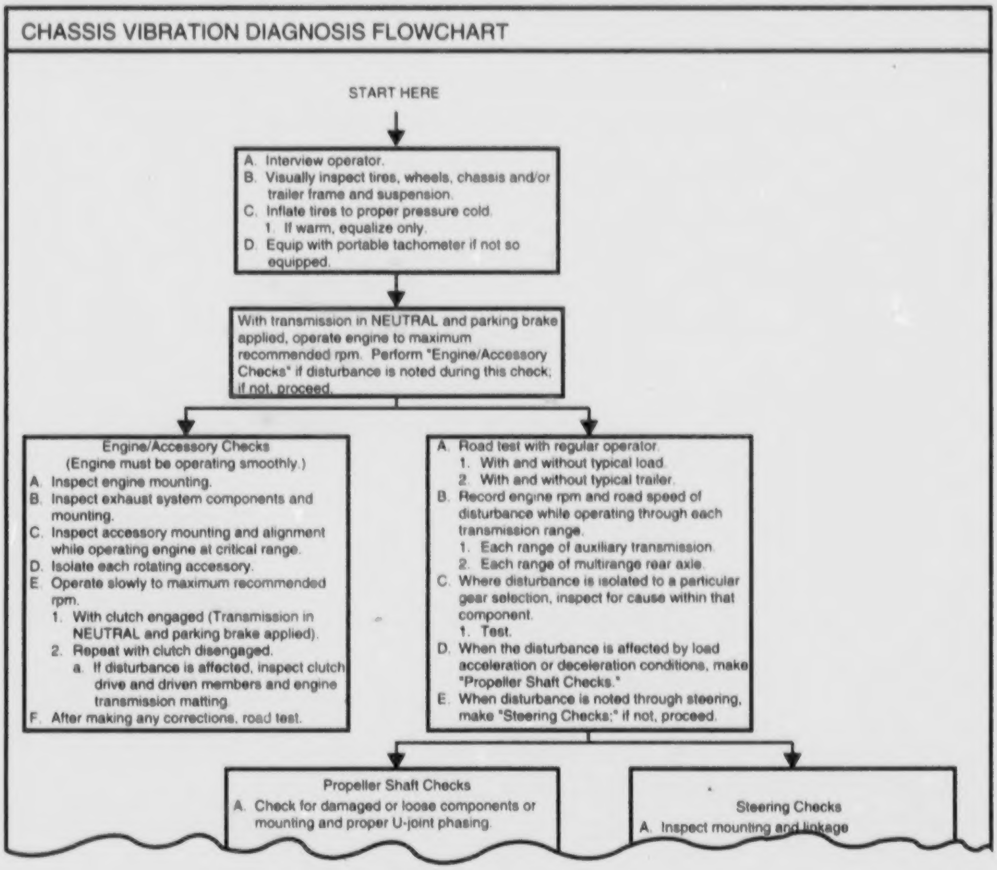
Oil Pressure Shutdown or Alarm Circuit

Note: If you do not understand the meaning of a symbol in a diagram, do not hesitate to ask someone or to check other references. Misunderstanding a schematic diagram could be a costly mistake.

d. **Flow diagrams** (also called flow charts or fault trees)

- Outline service procedures, especially in troubleshooting, when the technician must make choices based on test indications or inspection results
- Usually consist of boxes that contain text and that are connected by lines; the text in the boxes is normally a description of a step the service technician must perform or the possible result of the step just performed

Figure 7—Example of a flow diagram


CHASSIS VIBRATION DIAGNOSIS FLOWCHART
START HERE
A. Interview operator.
B. Visually inspect tires, wheels, chassis and/or trailer frame and suspension.
C. Inflate tires to proper pressure cold.
1. If warm, equalize only.
D. Equip with portable tachometer if not so equipped.
With transmission in NEUTRAL and parking brake applied, operate engine to maximum recommended rpm. Perform "Engine/Accessory Checks" if disturbance is noted during this check; if not, proceed.
Engine/Accessory Checks
(Engine must be operating smoothly.)
A. Inspect engine mounting.
B. Inspect exhaust system components and mounting.
C. Inspect accessory mounting and alignment while operating engine at critical range.
D. Isolate each rotating accessory.
E. Operate slowly to maximum recommended rpm.
1. With clutch engaged (Transmission in NEUTRAL and parking brake applied).
2. Repeat with clutch disengaged.
a. If disturbance is affected, inspect clutch drive and driven members and engine transmission matting.
F. After making any corrections, road test.
A. Road test with regular operator.
1. With and without typical load.
2. With and without typical trailer.
B. Record engine rpm and road speed of disturbance while operating through each transmission range.
1. Each range of auxiliary transmission.
2. Each range of multirange rear axle.
C. Where disturbance is isolated to a particular gear selection, inspect for cause within that component.
1. Test.
D. When the disturbance is affected by load acceleration or deceleration conditions, make "Propeller Shaft Checks."
E. When disturbance is noted through steering, make "Steering Checks;" if not, proceed.
Propeller Shaft Checks
A. Check for damaged or loose components or mounting and proper U-joint phasing.
Steering Checks
A. Inspect mounting and linkage

Courtesy of Cummins Engine Co., Inc.

Information Sheet

Objective 6

Basic parts of a reference table

a. **Title or name of table**—Identifies the purpose of the table

b. **Headings**—Tell the type of information contained in the column or row

Note: The first column in a table is particularly important because it usually shows how the information in the other columns is organized.

c. **Row**—Information is listed horizontally

d. **Column**—Information is listed vertically

e. **Entries**—Bits of information in columns and rows of a table

f. **Notes** (optional)

- Used to add or modify the information given in the table
- Are generally listed below the main body of the table

Figure 8—Basic parts of a reference table

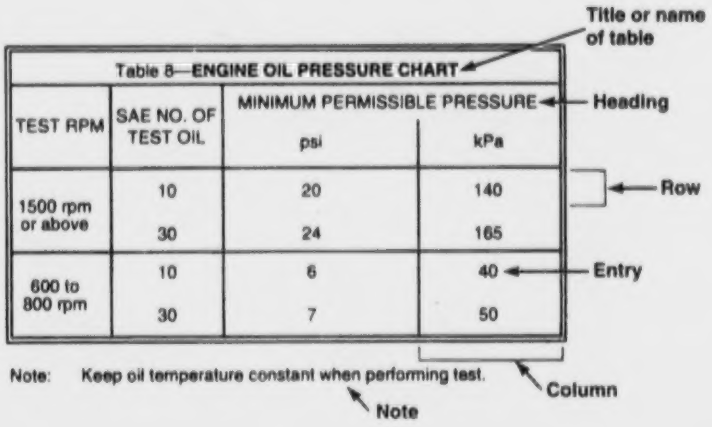


Table 8—**ENGINE OIL PRESSURE CHART**

TEST RPM	SAE NO. OF TEST OIL	MINIMUM PERMISSIBLE PRESSURE psi	kPa
1500 rpm or above	10	20	140
	30	24	165
600 to 800 rpm	10	6	40
	30	7	50

Note: Keep oil temperature constant when performing test.

Title or name of table
Heading
Row
Entry
Column
Note

Objective 7

Types of tables used in reference materials

a. **Specification table**—Used to provide specifications for operation, service, and overhaul of a specific make and model of equipment

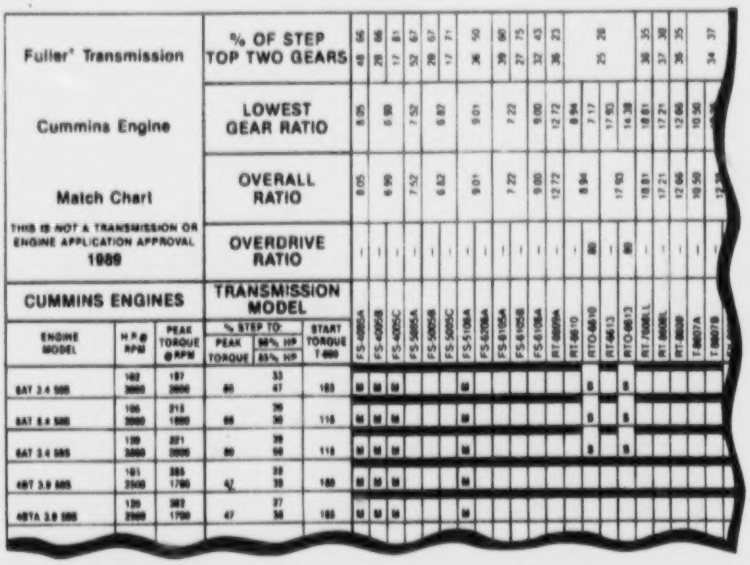
Figure 9—Example of a specification table

GOVERNOR SPRING CHART (1)				
Spring Part No.	8N8595	8N8596	8N8597	8N8598
Color Code And No. Of Stripes	one white one yellow	one blue one lt. green	one lt. blue one yellow	one lt. blue one lt. gray
Put a force on spring of:	17.8 N (4.00 lb)	17.8 N (4.00 lb)	17.8 N (4.00 lb)	12 N (2.7 lb)
Then add more force to make spring shorter by:	16.0 mm (.63 in)	14.16 mm (.557 in)	15.79 mm (.621 in)	16.0 mm (.63 in)
Total test force	35.3 ± 0.5 N (7.94 ± .11 lb)	32.16 ± 0.42 N (7.24 ± .09 lb)	32.16 ± 0.42 N (7.24 ± .09 lb)	24.8 ± 0.4 N (5.58 ± .09 lb)
Free length after test	76.0 ± 1.0 mm (2.99 ± .04 in)	76.0 ± 1.0 mm (2.99 ± .04 in)	76.0 ± 1.0 mm (2.99 ± .04 in)	76.0 ± 1.0 mm (2.99 ± .04 in)
Outside diameter	34.87 mm (1.373 in)	34.57 ± 0.38 mm (1.361 ± .015 in)	34.57 ± 0.38 mm (1.361 ± .015 in)	34.57 ± 0.38 mm (1.361 ± .015 in)

Permission to reprint granted by Caterpillar Inc.

b. **Application table**—Generally lists common factors (such as models of equipment, operating hours, or service procedures) as the column headings and then marks the applicable boxes in that column with a symbol such as an X or a check mark

Figure 10—Example of application table



Fuller® Transmission

Cummins Engine

Match Chart

THIS IS NOT A TRANSMISSION OR ENGINE APPLICATION APPROVAL

1989

% OF STEP TOP TWO GEARS

LOWEST GEAR RATIO

OVERALL RATIO

OVERDRIVE RATIO

CUMMINS ENGINES

TRANSMISSION MODEL

ENGINE MODEL

H.P.@ RPM

PEAK TORQUE @RPM

% STEP TO:

PEAK TORQUE

90% HP

85% HP

START TORQUE

FS-4005A

FS-4005B

FS-4005C

FS-5005A

FS-5005B

FS-5005C

FS-5106A

FS-6206A

FS-6105A

FS-6105B

FS-6106A

RT-6609A

RT-6610

RTO-6610

RT-6613

RTO-6613

RT-7608LL

RT-8608L

RT-8609

T-8607A

T-8607B

Courtesy of Eaton Corp.

c. **Problem-remedy table**—Lists problems and symptoms, their probable causes, and recommended repair or maintenance procedures that should correct or remedy the problems

Information Sheet

Figure 11—Example of problem-remedy table

ENGINE LUBRICATION SYSTEM TROUBLESHOOTING		
Problem	**Cause**	**Correction**
Excessive oil consumption	Too much lubrication oil in engine	Find where extra oil comes from. Remove extra oil. Make repairs as needed. Fill engine with oil to the FULL mark on the dipstick. Check correct oil level while engine is running. Do not overfill.
	Oil leaks	Find all oil leaks. Make repairs as needed. Check for dirty oil breather.
Engine oil pressure low	Dirty oil filter	Install new oil filter element if needed. Remove dirty oil from engine. Put clean oil in engine.
	Fuel in lubrication oil	Locate the area where fuel gets into the lubrication oil. Drain the lubrication oil. Install a new oil filter element. Fill the engine crankcase with clean oil.
	Defect in oil pressure gauge	Install new gauge.

Permission to reprint granted by Caterpillar Inc.

Objective 8

Assignment Sheet 1—Interpret Drawings Used in Diesel Equipment Reference Materials

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

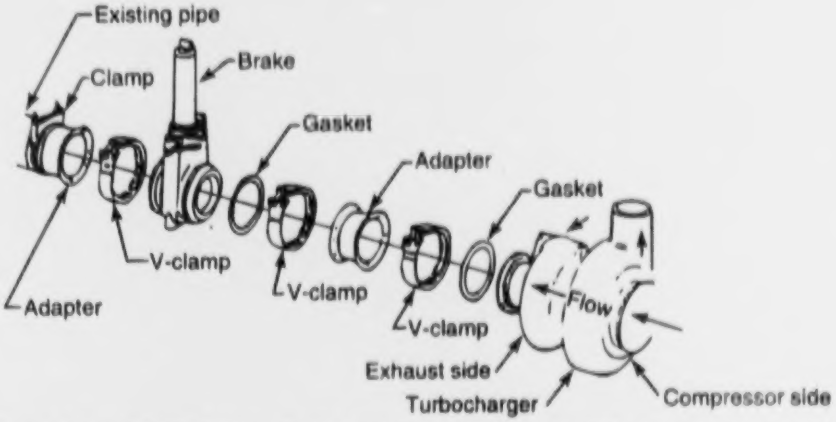
Basic Skills

Reading Writing Critical Thinking

Directions

Study the drawings shown in this assignment, then answer the questions coded by numbers for each drawing. Write your answers in the spaces provided.

Figure 1—Engine brake (turbocharged)


Existing pipe
Clamp
Brake
Gasket
Adapter
Gasket
Adapter
V-clamp
V-clamp
V-clamp
Flow
Exhaust side
Turbocharger
Compressor side

Reprinted from *MOTORS Heavy Truck Repair Manual.* ©Copyright 1985 by permission of the Hearst Corp.

1-1. Two gaskets fit between which three major parts?

______________, ______________, and ______________.

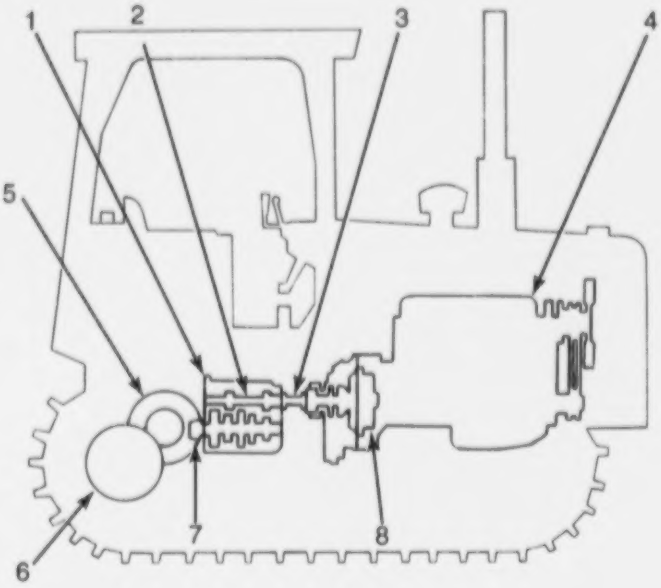
1-2. What kind of fastener connects those three parts? ______________

1-3. Which component is the first element in the system? (start of flow shown)

____

Assignment Sheet 1

Figure 2—Power train components



1. Transmission 2. Upper shaft (input and power take-off)
3. Universal joint 4. Diesel engine 5. Steering clutches
6. Final drives 7. Pinion shaft (lower and output) 8. Flywheel clutch

Permission to reprint granted by Caterpillar Inc.

2–1. What two components are connected by the universal joint?

______________________ and ______________________

2–2. What component transfers power from the engine to the universal joint?

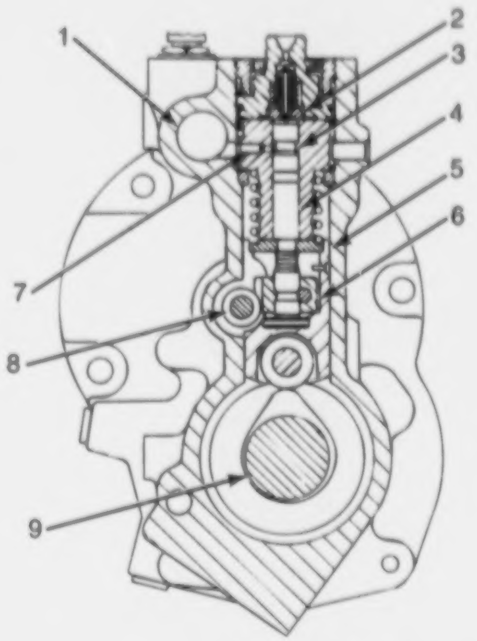
____

2–3. Which shaft transfers power to the steering clutches?

____

503

Figure 3—Fuel injection pump and housing (cross section view)



1. Inlet manifold 2. Check assembly 3. Pressure relief passage
4. Plunger 5. Lifter 6. Gear 7. Inlet passage 8. Fuel rack
9. Camshaft

Permission to reprint granted by Caterpillar Inc.

3–1. Is the camshaft solid or hollow?

____

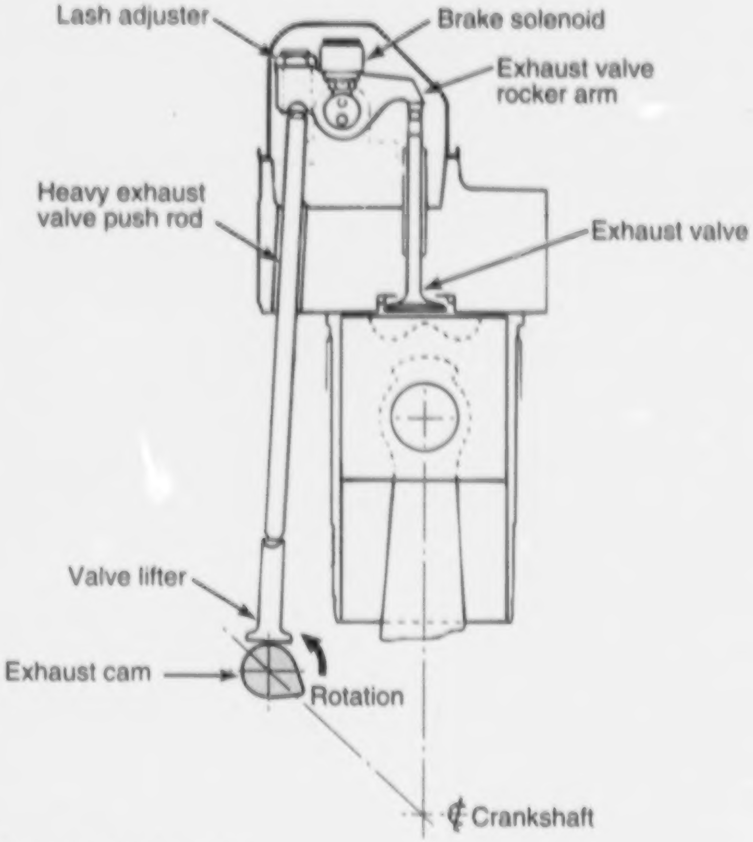
3–2. Movement of the fuel rack causes a part to rotate. Name that part.

____

3–3. The part that the fuel rack rotates is attached to another part. Name that third part.

____

Figure 4—Exhaust system


Lash adjuster
Brake solenoid
Exhaust valve rocker arm
Heavy exhaust valve push rod
Exhaust valve
Valve lifter
Exhaust cam
Rotation
¢ Crankshaft

Courtesy of Mack Trucks, Inc.

4–1. What is the exhaust cam's direction of rotation?

____

4–2. What effect does the camshaft's rotation have on the exhaust valve rocker arm?

____

4–3. What part is fastened with a hex nut?

____

4–4. Name one of the two parts moved by the rotation of the crankshaft.

____

Objective 9

Assignment Sheet 2—Interpret Graphs Used in Diesel Equipment Reference Materials

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Directions are followed	______
• Answers are correct	______

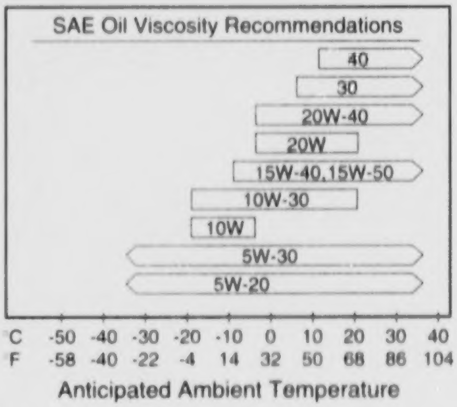
Basic Skills

Reading Writing Critical Thinking

Directions

Study the graphs shown in this assignment, then answer the questions coded by numbers for each graph. Write your answers in the spaces provided.

Figure 1



1–1. What single grade oil should be used if expected ambient temperatures range from 45°F to 95°F? ______________________

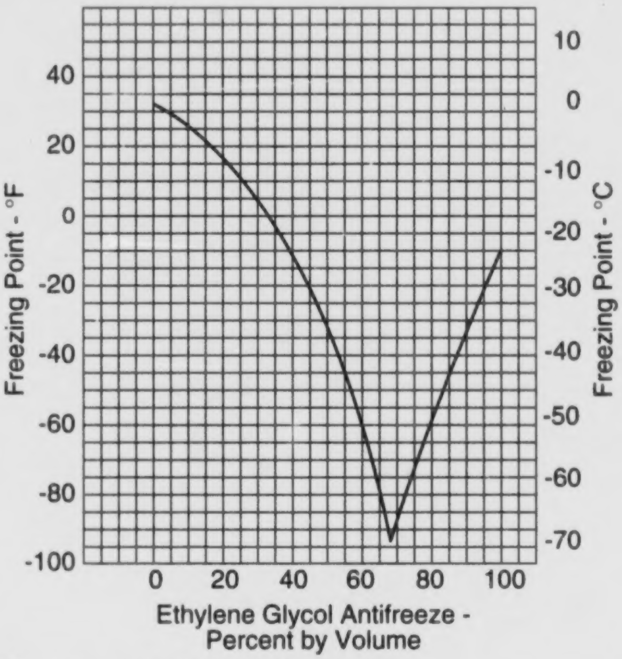
1–2. Which grade of oil can be used in the widest temperature range?

____

1–3. If ambient temperatures are expected to range from –5°C to 35°C, which multigrade oil would be best? ______________________

Assignment Sheet 2

Figure 2



Permission to reprint granted by Caterpillar Inc.

2–1. What is the approximate freezing point in degrees Fahrenheit of a coolant solution that contains 20 percent ethylene glycol antifreeze?

____

2–2. At approximately what percentage of ethylene glycol antifreeze content does a coolant peak in performance and then begin to lose its effectiveness?

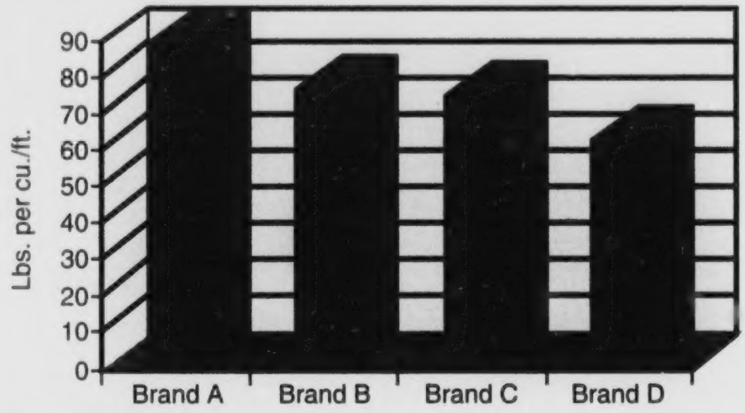
____

2–3. What percentage of ethylene glycol antifreeze should a coolant contain to provide protection to –20°C?

____

507

Figure 3—Facing density of gaskets



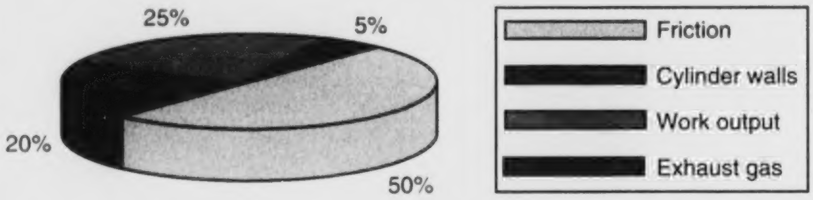
3–1. If greater facing density makes superior gaskets, which brand is best?

____

3–2. What is the approximate facing density of a Brand C gasket?

____

Figure 4—Energy produced in a diesel engine



4–1. What percentage of energy is available as work output?

____

4–2. What percentage of energy is lost for various reasons?

____

Objective 10

Assignment Sheet 3—Interpret Diagrams Used in Diesel Equipment Reference Materials

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

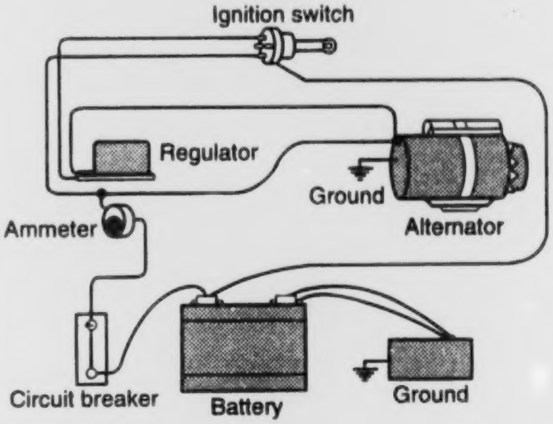
Basic Skills

Reading Writing Critical Thinking

Directions

Study the diagrams shown in this assignment, then answer the questions coded by numbers for each diagram. Write your answers in the spaces provided.

Figure 1


Ignition switch
Regulator
Ground
Ammeter
Alternator
Circuit breaker
Battery
Ground

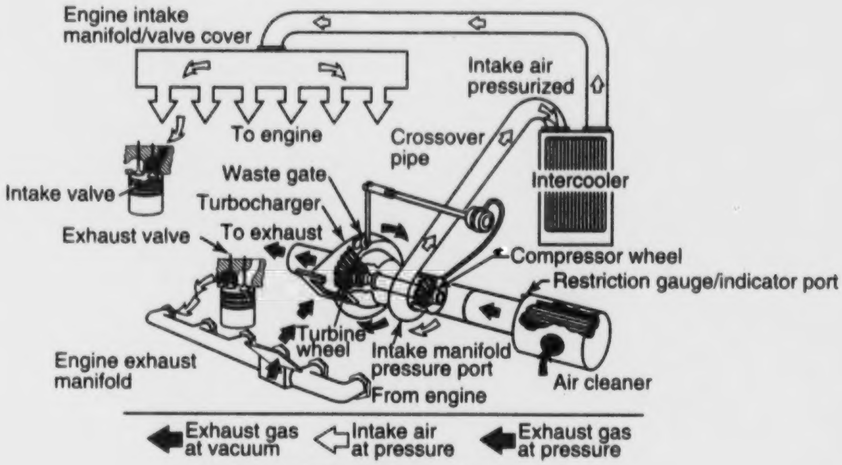
1–1. The ignition switch has three wires. One is connected to the battery. The other two connect the ignition switch to three other components. Name those three components.

_______________, _______________, and _______________ .

1–2. Which two components are connected to ground?

_______________ and _______________

Figure 2—Exhaust system


Engine intake manifold/valve cover
Intake air pressurized
To engine
Crossover pipe
Waste gate
Intercooler
Intake valve
Turbocharger
Exhaust valve
To exhaust
Compressor wheel
Restriction gauge/indicator port
Turbine wheel
Intake manifold pressure port
Engine exhaust manifold
From engine
Air cleaner
Exhaust gas at vacuum
Intake air at pressure
Exhaust gas at pressure

AIR INDUCTION/EXHAUST SYSTEM

Reprinted with the permission of NAVISTAR International Transportation Corp.

2–1. Where does air enter the air induction system?

____

2–2. Where does the air become pressurized?

____

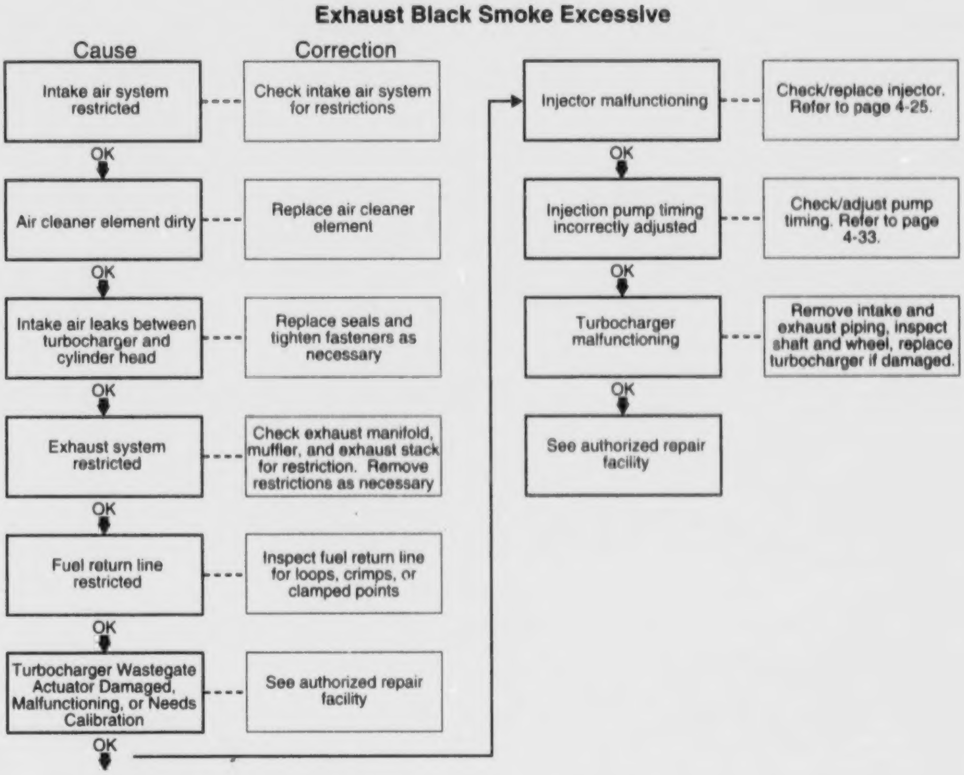
2–3. Where does the air go after it leaves the turbocharger?

____

2–4. Where does the exhaust go when it leaves the exhaust manifold?

____

Figure 3—Exhaust system


Exhaust Black Smoke Excessive
Cause
Correction
Intake air system restricted
Check intake air system for restrictions
OK
Air cleaner element dirty
Replace air cleaner element
OK
Intake air leaks between turbocharger and cylinder head
Replace seals and tighten fasteners as necessary
OK
Exhaust system restricted
Check exhaust manifold, muffler, and exhaust stack for restriction. Remove restrictions as necessary
OK
Fuel return line restricted
Inspect fuel return line for loops, crimps, or clamped points
OK
Turbocharger Wastegate Actuator Damaged, Malfunctioning, or Needs Calibration
See authorized repair facility
OK
Injector malfunctioning
Check/replace injector. Refer to page 4-25.
OK
Injection pump timing incorrectly adjusted
Check/adjust pump timing. Refer to page 4-33.
OK
Turbocharger malfunctioning
Remove intake and exhaust piping, inspect shaft and wheel, replace turbocharger if damaged.
OK
See authorized repair facility

Courtesy of Cummins Engine Co., Inc.

3–1. If the engine is emitting excessive black exhaust smoke and the air cleaner element (filter) is clean, what is the next likely cause of the problem?

____

3–2. If the exhaust system is restricted, what steps should the technician take to correct the problem?

____

3–3. If the problem continues after any fuel line restrictions are eliminated, what is the next step the technician should take?

____

3–4. What steps should the technician take if the turbocharger is malfunctioning?

____

Objective 11

Assignment Sheet 4—Interpret Tables Used in Diesel Equipment Reference Materials

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Directions are followed	______
• Answers are correct	______

Basic Skills

Reading Writing Critical Thinking

Directions

Study the tables shown in this assignment, then answer the questions coded by numbers for each table. Write your answers in the spaces provided.

Figure 1

Component or System	Liters	U.S. Gallons	Imperial Gallons
Engine Crankcase	27.5	7.25	6
Power Train (1) Oil System	77	20.5	17
Cooling System	34	9	7.5
Final Drives (Each)	11	3	2.5
Implement Hydraulic Tank	42	11	6
Fuel Tank	246	65	54
Winch Sump	43.5	16.5	13.7

(1) Quantity of oil in transmission can be increased up to 10 percent when operating on severe slopes. When the machine is returned to normal slope operation, remove the excess oil.

Permission to reprint granted by Caterpillar Inc.

1–1. How many U.S. gallons of fuel can the tractor hold? ______________

1–2. How many liters of coolant does the tractor require? ______________

1–3. How many imperial gallons of oil does the engine need? ____________

1–4. What is the maximum amount of additional transmission oil (in U.S. gallons) that can be added if the tractor is being operated on a severe slope? _____

Assignment Sheet 4

Figure 2

Pistons and Piston Rings			
	(1)Top Ring	**(2) Intermediate Ring**	**(3) Oil Control Ring**
Part No.	*9L6932	*9L6933	**9L6934
Width of groove in piston for piston ring (new)	*** —	*** —	.1255 = .0005 in. (3.188 = 0.013 mm)
Thickness of piston ring (new)	*** —	*** —	.1235 = .0005 in. (3.137 = 0.013 mm)
Clearance between groove and piston ring (new)	*** —	*** —	.0020 = .0010 in. (0.051 = 0.025 mm)
Maximum permissible clearance (worn)	*** —	*** —	.006 in. (0.15 mm)
Clearance between ends of piston ring when installed in a cylinder liner with a bore size of 4.7500 in. (120.650 mm)	.0245 = .0075 in. (0.622 = 0.191 mm)	.0245 = .0075 in. (0.622 = 0.191 mm)	.0225 = .0075 in. (0.572 = 0.191 mm)
Increase in clearance between ends of piston ring for each .001 in. (0.03 mm) increase in cylinder liner bore size		.003 in. (0.08 mm)	

*Install piston ring with "UP" side toward top of piston.

NOTE: 9L6932 Top Ring (1) has the mark "UP-1".

9L6933 Intermediate Ring (2) has the mark "UP-2".

**Install 9L6934 Oil Control Ring (3) with the gap in the spring 180° away from the gap in the ring.

****"Keystone" style piston rings and goves in pistons. The 5P4812 KEYSTONE PISTON RING GROOVE GAUGE is necessary for measuring these grooves. Put the pin end (A) of gauge "2" in the groove at four places around the circumference. Do this to both grooves. The flat edge (B) of the gauge must be between grooves (1) and (2). If there is clearance between the flat edge (B) of the gauge and the piston at all test locations, for both grooves, the piston is reusable. If the flat edge (B) is in contact with the piston, at any of the test locations, the piston is not reusable. Install a new piston.

Permission to reprint granted by Caterpillar Inc.

2–1. What is the intermediate ring's part number? ____________________

2–2. Which side of the top ring should be installed toward the top of the piston?

____

2–3. Which ring has a spring whose installation requires special positioning?

____

2–4. What tool is needed to measure the width of grooves in the top ring and intermediate ring? ________________________________

2–5. What is the clearance range in inches between the ends of the oil control ring when it is installed in a cylinder with a bore size of 4.7500 inches?

____

Figure 3

Current PT (Type G) Governor Plungers

Code	Red	Blue	Green	Yellow	Orange	Black	Gray	Purple	Usage	Code Letter
Size	0	1	2	3	4	5	6	7		–
Part No.	169660	169661	169662	169663	169664	169665	169666	169667	Standard	J
Part No.	182530	182531	182532	182533	182534	182535	182536	182537	SVS. Gov.	–
Part No.	159320	159321	159322	159323	159324	159325	161586	161587	JT	G
Part No.	168630	168631	168632	168633	168634	168635	168636	168637	V12,H,J,V6,V8	H
Part No.	203350	203351	203352	203353	203354	203355	203356	203357	Lower VS	
Part No.	213240	213241	213242	213243	213244	213245	213246	213247	V-378 V-504, V-555	
Part No.	212350	212351	212352	212353	212354	212355			Upper VS	
Part No.	213610	213611	23612	213613	213614	213615			Upper VS	
Part No.	3009380	3009381	3009382	3009383	3009384	3009385	3009386	3009387	AFC-5° End	
Part No.	3015487	3015488	3015489	3015490	3015491	3015492			Upper YS	
Part No.	3015243	3015244	3015245	3015246	3015247	3015248	3015249	3015250	PT-H Lower	

Current PT (Type R) Governor Plungers

Code	Red	Blue	Green	Yellow	Orange	Black	Usage	Code Letter
Size	0	1	2	3	4	5		
Part No.	102510	102511	102512	102513	115584	115585	Standard	A
Part No.	70810	151941	151942	151943	151944	151945	MVS. Gov.	D
Part No.	114690	114691	114692	114693	115604	115605	MVS. Gov.	C
Part No.	151970	151971	151972	151973	151974	151975	MVS. Gov.	E
Part No.	105030	105031	105032	105033	115554	115555	Torque Converter Governor	K
Part No.	159410	159411	159412	159413	159414	159415	Torque Converter Governor	M
Part No.	109960	109961	109962	109963	109964	115915	Road Speed Gov.	B
Part No.	161110	161111	161112	161113	161114	161115	MVS Gov. with PT (type B) Injectors	F

Permission to reprint granted by Caterpillar Inc.

3–1. If a green governor plunger has the code letter K, what part number should the technician use to replace it? ____________________

3–2. What color is plunger number 159414? ____________________

3–3. What type of governor is plunger number 115555 used in? __________

3–4. What size is plunger number 151941? ____________________

3–5. What color is any plunger whose part number ends with the number 5?

____

Assignment Sheet 4

Figure 4

Lubrication and Maintenance Chart			
Item	**Service**	**Lube.**	**Page**
When Required			
Cutting Edges and End Bits	Inspect—replace if worn or damaged.		90
Ripper Tips	Inspect—replace if worn or damaged.		91
Winch	Inspect cable—replace frayed, kinked or worn cable.		92
Windshield Wipers and Washer	Replace wiper blades—fill the washer reservoir.		93
Fuses	Replace if element separates.		94
Ether Starting Aid	Replace ether cylinder when empty.		95
Engine Air Intake	Service when indicated.		96
Water Separator	Replace filter elements.		101
Cooling System Relief Cap	Replace if necessary.		102
Bulldozer Ball and Socket	Inspect adjustment.		103
Flywheel Clutch and Brake—Direct Drive	Adjust clutch and brake.		104
Fuel Filter Element (If equipped)	Service when gauge indicates low fuel pressure		106
Every 10 Service Hours or Daily			
Walk-Around Inspection	Inspect machine.		109
Engine Crankcase	Measure oil level.	CD	112
Power Train Oil System	Check oil level.	CD/TO-2	113
Radiator	Check coolant level.		114
Hydraulic Tank	Check oil level.	HYDO	115
Fuel Tank	Drain water and sediment.		116
Indicators and Gauges	Test for proper function.		116
Winch	Check oil level.	CD/TO-2	117
Water Separator	Drain water.		117
Fuel Filter Element	Service when gauge indicates low pressure.		118
Every 50 Service Hours or Weekly			
Batteries	Check electrolyte level in the non-low maintenance high output batteries		119
Ripper Linkage and Cylinder Bearings	Lubricate fittings.	MPG	120
Cab Air System	Clean filters (service daily in very dusty conditions)		120
Bulldozer Cylinder Support Bearings	Lubricate fittings.	MPG	123
Track Roller Frame Bearings	Lubricate fittings.	MPG	124
Power Train Oil System	Change filters on new or reconditioned power shift transmissions only	CD/TO2	124
Equalizer Spring Pivot Pin	Lubricate fittings.	MPG	125
Flexible Coupling—Power Shift	Lubricate fittings.	MPG	125
Every 100 Service Hours or 2 Weeks			
Operator's Seat—Special Application	Lubricate fittings.	MPG	126
Hydraulic Control Linkage (If Equipped)	Lubricate fittings.	MPG	126
Sprocket Hub Bearings	Inspect adjustment if sprocket is loose or if leaks are present.	MPG	126

continued on next page

Figure 4—continued

Lubrication and Maintenance Chart			
Item	**Service**	**Lube.**	**Page**
Every 250 Service Hours or Monthly			
Engine Crankcase	Change oil and filters.	CD	127
Cooling System	Coolant conditioner.		129
Air Conditioner	Test operation.		130
Belts—Alternator, Fan, and Air Conditioner	Inspect—replace and/or adjust		130
Fan Pulley Bearing	Lubricate fitting.	MPG	132
Brakes	Check adjustment.		134
Tracks	Check track adjustment.		134
Bulldozer Tilt Brace	Lubricate fittings.	MPG	136
Batteries	Check electrolyte level in the low maintenance high output batteries.		136
Final Drives	Check oil level.	CD/TO-2	136
Power Train Oil System	Change filters.	CD/TO-2	137
Every 500 Service Hours or 3 Months			
Fuel Filter Element	Change Filter.		140
Engine Crankcase Breather	Clean and oil.	CD	142
Hydraulic System	Change filter.	HYDO	143
Fuel Tank Cap and Fill Screen	Clean cap and screen.		145
Winch Filter and Magnetic Strainer	Change filter and clean strainer	CD/TO-2	147
Equalizer Bar	Inspect.		149
Every 1000 Service Hours or 6 Months			
Power Train Oil System (Power Shift)	Change oil and filters—clean breathers.	CD/TO-2	150
Rollover Protective Structure (ROPS)	Torque bolts.		154
Winch Oil System	Change oil and clean breather.	CD/TO-2	154
Universal Joint	Lubricate fittings	MPG	155
Final Drives	Change oil.	CD	156
Every 2000 Service Hours or 1 Year			
Hydraulic System	Change oil.	HYDO	157
Engine Valve Lash	Adjust if necessary.		159
Engine Valve Rotators	Observe rotators.		160
Cooling System	Change coolant.		160
Power Train Oil System (Direct Drive)	Change oil and filters—clean breather and suction screen.	CD/TO-2	163
Sprocket Hub Bearings	Inspect—adjust if sprocket is loose or leaks are present.		166

Permission to reprint granted by Caterpillar Inc.

BEST COPY AVAILABLE

Assignment Sheet 4

Note: Questions 4–1 through 4–6 refer to the two-page chart in Figure 4.

4–1. How often should the electrolyte level in the non-low maintenance high output batteries be checked?

4–2. What type of lubricant does the engine crankcase require?

4–3. What kind of service should the equalizer spring pivot pin receive every 50 service hours?

4–4. What should be done to the engine crankcase breather every 3 months?

4–5. Where would you look in the service manual for instructions on how to lubricate the operator's seat fittings?

4–6. How often should the brake adjustment be checked?

517

Objective 12

Assignment Sheet 5—Use Reference Materials to Answer Specific Questions

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

Basic Skills

Reading Writing Critical Thinking

Materials List

- Reference manuals
- Engine or piece of equipment

Directions

Using appropriate reference materials in your facility and an assigned engine or piece of equipment, answer the questions indicated by your instructor. Write your answers in the spaces provided.

1. Name of equipment ______________________
2. Manufacturer ______________________
3. Model number ______________________
4. Equipment serial number ______________________
5. Engine manufacturer ______________________
6. Engine model number ______________________
7. Engine serial number ______________________

Assignment Sheet 5

Note: Service manuals and many parts manuals and other reference materials generally explain what each number and letter in an engine serial number means. This explanation is usually given near the front of the document. Locate that information for your assigned equipment to answer the following questions.

8. On the lines below, list each element of the engine serial number and explain its significance.

    ____

    ____

    ____

    ____

9. What is the horsepower rating of the engine and at what engine speed is that calculated?

    Horsepower—______________________________

    Engine speed—______________________________

10. What is the displacement of the engine?

    ____

11. What is the oil capacity of the engine?

    ____

12. What viscosity of oil is recommended for the engine when the temperature is expected to reach 10°F before the next oil change?

    ____

13. What section of the engine service manual covers the equipment's ignition system?

    ____

14. How often should the engine oil be changed?

    ____

15. What is the the maximum engine speed allowed?

    ____

519

Unit 4-A

Measuring Instruments

Unit Contents

Student Components

Student Page

Objective Sheet 4A-3

Information Sheet 4A-5

Assignment Sheets

1—Read U.S. Customary and Metric Rules 4A-25
2—Draw Lines to Specified Lengths 4A-33
3—Measure Lines Using a Steel Rule 4A-35
4—Measure Lines on Objects 4A-37
5—Measure Circle Diameters 4A-39
6—Read Standard and Metric Micrometers 4A-41

Job Sheets

1—Use a Dial Caliper 4A-47
2—Use an Outside Micrometer 4A-49
3—Use an Inside Micrometer 4A-53
4—Use Telescoping Gauges 4A-57
5—Use a Dial Indicator 4A-59
6—Check a Torque Wrench For Accuracy 4A-63
7—Use a Small Hole Gauge to Measure Valve Guide Diameter .. 4A-65
8—Use a Cylinder Bore Gauge 4A-67

Objective Sheet

Unit Objective

After completing this unit, the student should be able to read and use common measuring instruments. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to measuring instruments with their definitions.
2. Distinguish between basic measurement systems.
3. Identify types of rules used by diesel technicians.
4. Select basic units of measurement found on rules.
5. Select true statements concerning guidelines for using rules.
6. Identify types of calipers.
7. Identify parts of a dial caliper.
8. Select true statements concerning guidelines for care of calipers.
9. Identify types of micrometers.
10. Identify the parts of an outside micrometer.
11. Explain how to select the proper size outside micrometer.
12. Select true statements concerning methods for checking accuracy of an outside micrometer.
13. Identify the parts of an inside micrometer.
14. Match accessories for an inside micrometer with their uses.
15. Select uses of an inside micrometer.
16. Select true statements concerning methods for checking accuracy of an inside micrometer.
17. Complete statements concerning rules for use and care of micrometers.
18. Match types of gauges with their uses.
19. Identify parts of a dial indicator set.
20. Identify types of torque wrenches.

21. Complete statements concerning the use and care of torque wrenches.
22. Identify types of feeler gauges.
23. Distinguish between instruments used to measure angles.
24. Read U.S. customary and metric rules. (Assignment Sheet 1)
25. Draw lines to specified lengths. (Assignment Sheet 2)
26. Measure lines using a steel rule. (Assignment Sheet 3)
27. Measure lines on objects. (Assignment Sheet 4)
28. Measure circle diameters. (Assignment Sheet 5)
29. Read standard and metric micrometers. (Assignment Sheet 6)
30. Use a dial caliper. (Job Sheet 1)
31. Use an outside micrometer. (Job Sheet 2)
32. Use an inside micrometer. (Job Sheet 3)
33. Use telescoping gauges. (Job Sheet 4)
34. Use a dial indicator. (Job Sheet 5)
35. Check a torque wrench for accuracy. (Job Sheet 6)
36. Use a small hole gauge to measure valve guide diameter. (Job Sheet 7)
37. Use a cylinder bore gauge. (Job Sheet 8)

Information Sheet

Objective 1

Terms and definitions

a. **Bezel**—Rim that holds a transparent covering such as on watch, clock, or dial indicator

b. **Caliper**—Measuring instrument having two usually adjustable arms, legs, or jaws used to measure diameter or thickness

c. **Dial indicator**—Precision instrument or gauge that consists of a face with marked graduations and a pointer

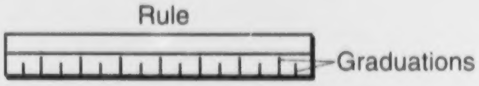
d. **Digital readout**—Display on an electronic device that shows measured data in numerical digits

Note: Many measuring instruments are available with digital readout.

e. **Gauge**—Instrument with a graduated scale or dial for measuring or indicating quantity

f. **Graduation**—Marking found on rules and scales to denote basic units of measurement

Figure 1

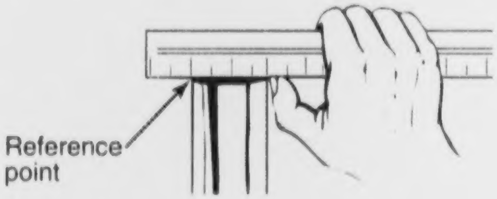


g. **Instrument**—Any measuring device designed for precision work; may be mechanical or electrical/electronic

h. **Micrometer**—Precise measuring instrument that consists of a spindle moved by a finely threaded screw

i. **Reference point**—Starting point of measurement for both workpiece and rule

Figure 2



j. **Rule**—Measuring tool consisting of a strip of material marked off in units

k. **Torque**—Turning or twisting force commonly used to measure nut tightness

Formula: Torque = Force x Distance

Objective 2

Basic measurement systems

	U.S. Customary Units	Metric Units
LENGTH	Mile Yard Foot Inch	Kilometer Meter Decimeter Centimeter Millimeter
CAPACITY	Gallon Quarter Pint Cup	Kiloliter Liter Milliliter
WEIGHT	Pound Ounce	Kilogram Gram Milligram

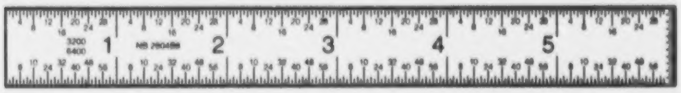
Note: Although U.S. customary measurements can be converted to metric measurements (and vice versa), this is not the preferred method. Typically, metric equipment/parts are measured with metric tools with their specifications expressed in metric units. The same is true for U.S. tools and measurements. Most tools and instruments are designed for only one system although some (especially digital) instruments are capable of making either metric or U.S. measurements. Make sure you are using the correct tools (metric or U.S.) for the required job.

Objective 3

Types of rules used by diesel technicians

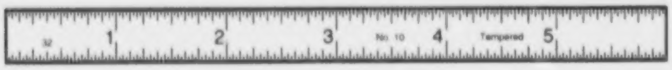
a. **Steel rule**

Figure 3



b. **Narrow flexible rule**

Figure 4


1
2
3
No 10
4
Tempered
5

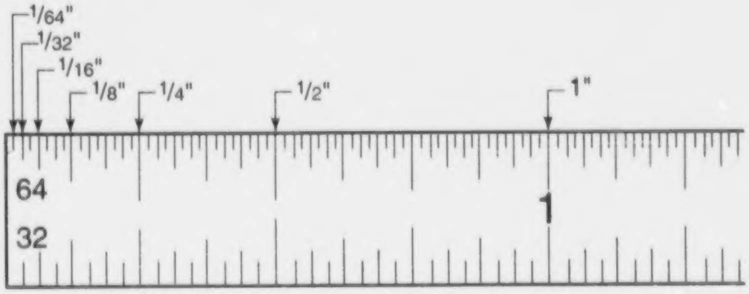
Objective 4

Basic units of measurement found on rules

a. **Fractional**

- Eighths (1/8")
- Sixteenths (1/16")
- Thirty-seconds (1/32")
- Sixty-fourths (1/64")

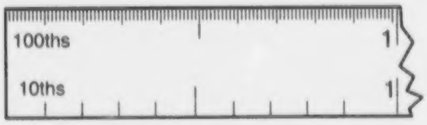
Figure 5


1/64"
1/32"
1/16"
1/8"
1/4"
1/2"
1"
64
32
1

b. **Decimal**

- Tenths (0.1)
- Hundredths (0.01)

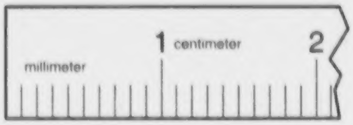
Figure 6


100ths
1
10ths
1

c. **Metric**

- Decimeter (0,1m)
- Centimeter (0.01m)
- Millimeter (0.001m)

Figure 7



Objective 5

Guidelines for using rules

a. Use a good quality rule.

b. Do not bend or distort a steel rule.

c. Use rule only for its intended purpose as a measuring tool.

Note: A steel rule used to scrape gasket material or grease off of parts will ultimately become bent, marred, and inaccurate.

d. Use the proper length and graduation.

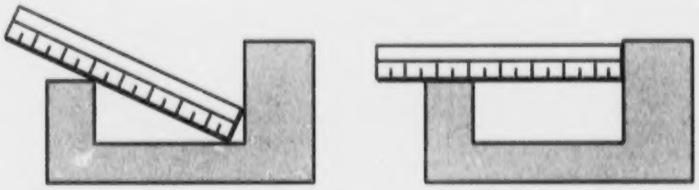
e. Use finest graduation for accuracy.

Note: The use of "half an eighth," or "about two-thirds of a thirty-second" will not provide accurate measurements. Always use a rule with sufficiently fine graduations to obtain an accurate measurement.

f. Use whole unit graduation as reference for accuracy.

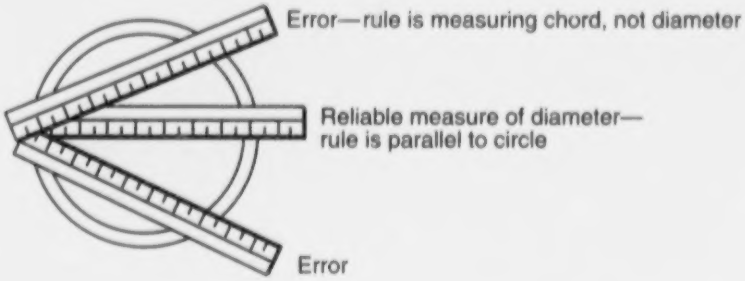
g. Use rule on edge for better reading.

Figure 8



h. Use the rule along axis parallel to plane of measurement.

Figure 9

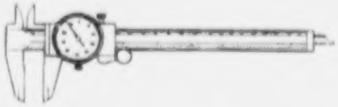

Error—rule is measuring chord, not diameter
Reliable measure of diameter—rule is parallel to circle
Error

Objective 6

Types of calipers

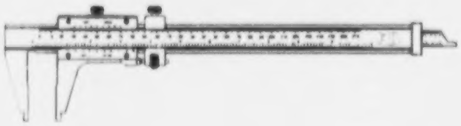
a. Dial

Figure 10



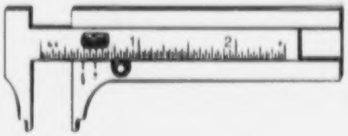
b. Vernier

Figure 11



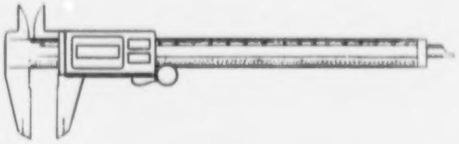
c. Slide

Figure 12



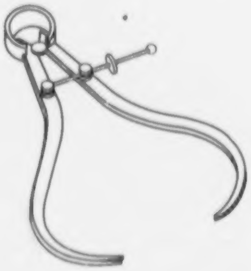
d. Digital readout (or electronic)

Figure 13



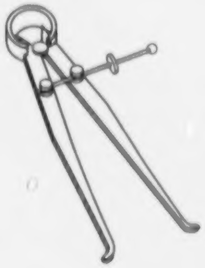
e. Machinist's outside

Figure 14



f. Machinist's inside

Figure 15

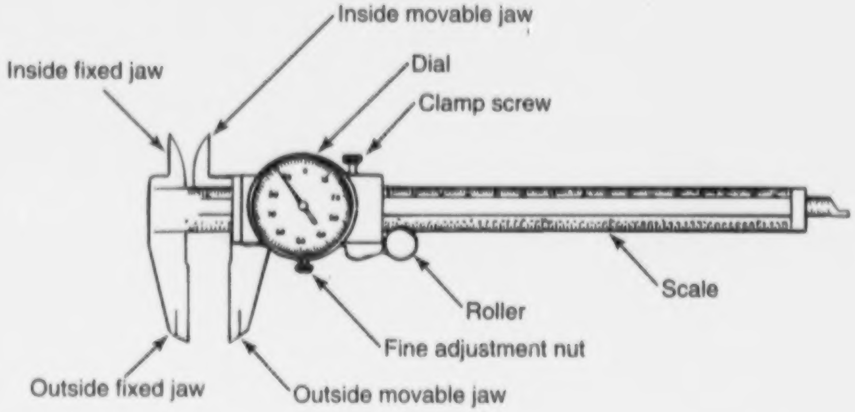


Information Sheet

Objective 7

Parts of a dial caliper

Figure 16


Inside movable jaw
Inside fixed jaw
Dial
Clamp screw
Scale
Roller
Fine adjustment nut
Outside fixed jaw
Outside movable jaw

Objective 8

Guidelines for care of calipers

a. Keep the caliper free of dust, grit, and grease.

b. Gently clean the caliper with a soft, lint-free cloth and light machine oil to prevent corrosion.

c. Keep the caliper in its case when it is not being used. Do not store it with other tools.

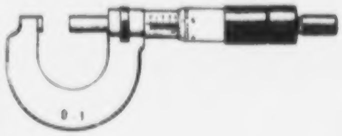
d. When storing, leave a gap between the fixed and movable jaws to allow for the expansion and contraction of the metal in the caliper.

Objective 9

Types of micrometers

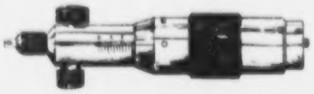
a. Outside

Figure 17



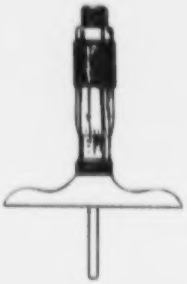
b. Inside

Figure 18



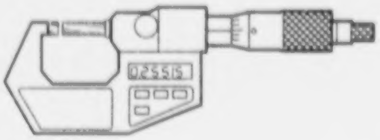
c. Depth

Figure 19



d. Digital readout (or electronic)

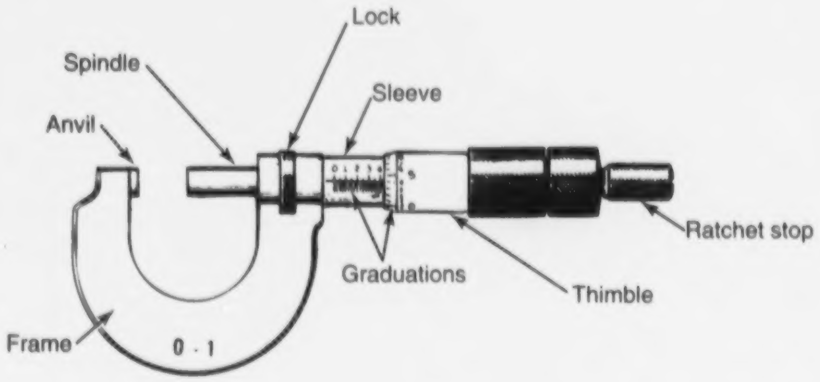
Figure 20



Objective 10

Parts of an outside micrometer

Figure 21


Lock
Spindle
Sleeve
Anvil
Ratchet stop
Graduations
Thimble
Frame
0 - 1

Information Sheet

Objective 11

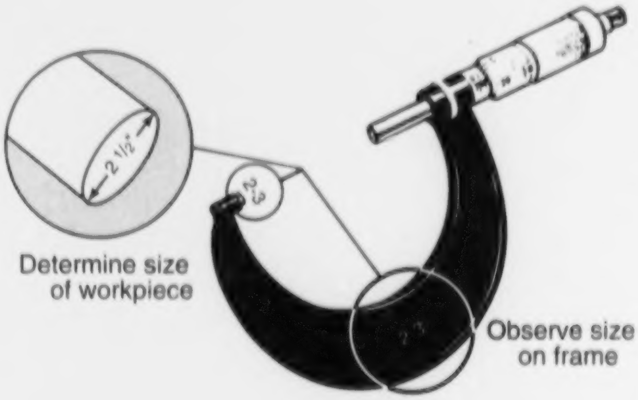
Selecting the proper size outside micrometer

a. Determine the approximate size of the workpiece.

b. Observe the capacity of the outside micrometer on the frame.

Note: On variable range micrometers, the capacity of the micrometer is located on each anvil.

Figure 22


2 1/2"
2-3
Determine size of workpiece
2-3
Observe size on frame

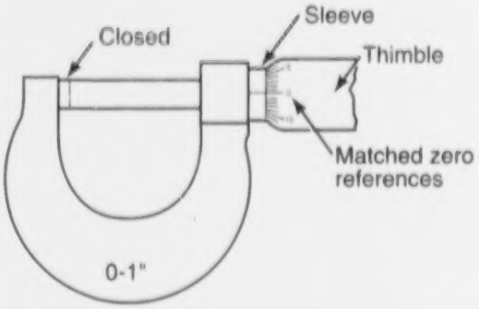
Objective 12

Methods for checking accuracy of an outside micrometer

a. 0" - 1.000" micrometer

- Clean anvil and spindle surfaces.
- Close spindle and anvil together.
- Observe zero references on the sleeve and thimble to make sure they line up perfectly.

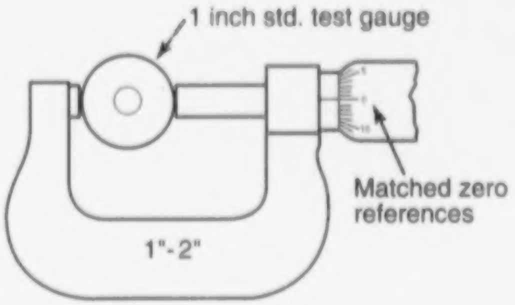
Figure 23


Closed
Sleeve
Thimble
Matched zero references
0-1"

b. Any micrometer over 1"

- Clean anvil and spindle surfaces.
- Use a standard bar or disc to check the minimum capacity.
- Observe zero references on the sleeve and thimble to make sure they line up perfectly.

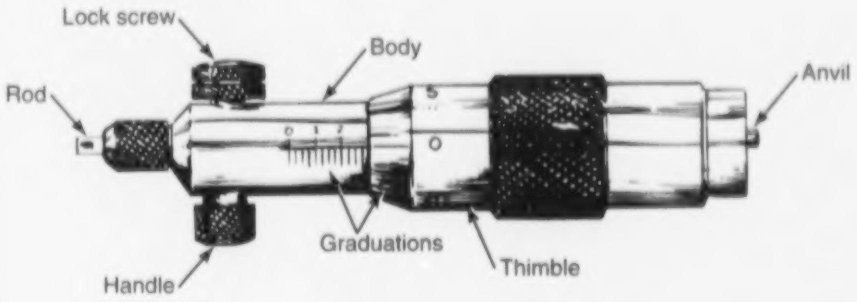
Figure 24


1 inch std. test gauge
Matched zero references
1"-2"

Objective 13

Parts of an inside micrometer

Figure 25

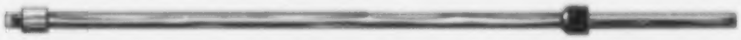

Lock screw
Body
Anvil
Rod
0 1 2
5
0
Graduations
Thimble
Handle

Objective 14

Accessories used with an inside micrometer

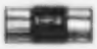
a. **Extension rods**—Extend the measuring capacity of the base unit

Figure 26



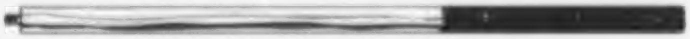
b. **Extension collar**—Locks the extension rod to the base unit and extends the measuring capacity by 0.500"

Figure 27



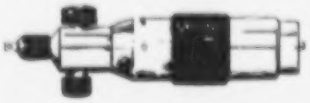
c. **Extension handle**—Used to measure in hard-to-reach places

Figure 28



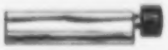
d. **Base unit or (head)**—Available in various ranges of measurement

Figure 29



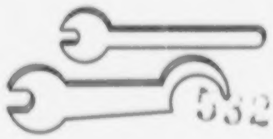
e. **Height gauge base**—Enables the micrometer to be used for inspection or setup work

Figure 30



f. **Wrench**—Used to adjust micrometer accuracy

Figure 31



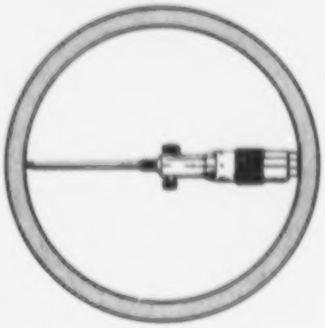
Objective 15

Uses of an inside micrometer

a. Measure inside diameter.

Examples: Camshaft bores, cylinder bores, main bearing bores, connecting rod bores

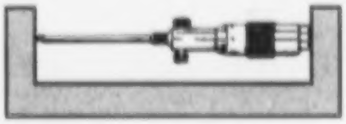
Figure 32



b. Measure width.

Examples: Slots, grooves

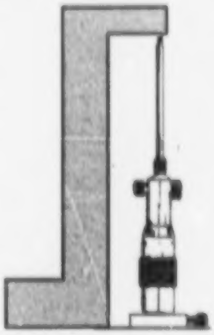
Figure 33



c. Measure height.

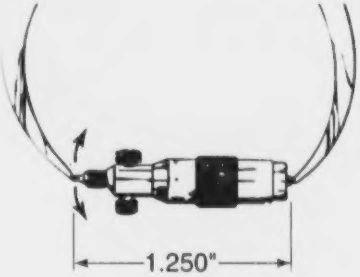
Note: A base attachment should be used.

Figure 34



d. Transfer measurement to machinist's outside caliper.

Figure 35

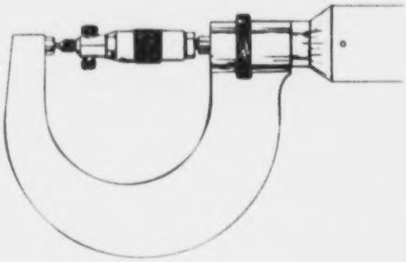


Objective 16

Methods for checking accuracy of an inside micrometer

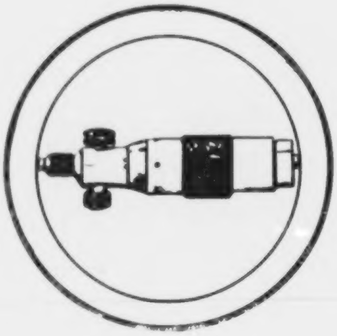
a. Measure the zero reference of an inside micrometer with an accurate outside micrometer.

Figure 36



b. Measure an object of known accurate measurement or use a standard ring gauge.

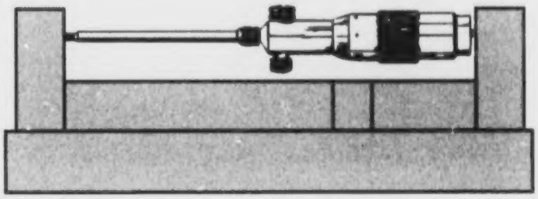
Figure 37



534

c.. Use a gauge block holder and gauge blocks to check an extension bar measurement.

Figure 38



Objective 17

Rules for use and care of micrometers

a. Keep micrometers away from heat, abrasive dust, moisture, oil, and grease.

b. Clean the anvil and spindle/rod with a soft, lint-free cloth and light machine oil to prevent corrosion.

c. Check the micrometer for accuracy against a standard before use. If the micrometer is dropped, do not use it again until it has been checked for accuracy. It may need to be adjusted.

d. Observe for worn or loose parts.

e. Do not overtighten the micrometer during measurement.

f. Keep the micrometer in its case or box when it is not being used. Do not store it with other tools.

g. Use micrometer only for its intended purpose as a measuring instrument.

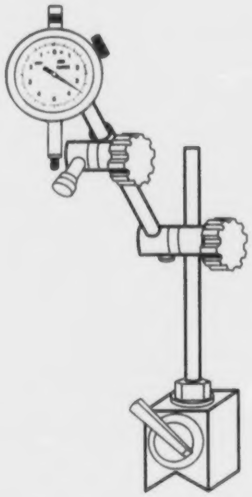
Note: Do not use a micrometer as a "C" clamp.

Objective 18

Types of gauges and their uses

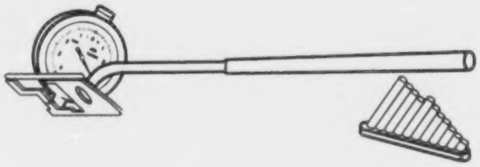
a. **Dial indicator**—Used to measure runout, roundness, and wear on various components (such as bushings, bearings, tie rod, ball joint, cam and valve guide, etc.); measurement is registered on dial

Figure 39



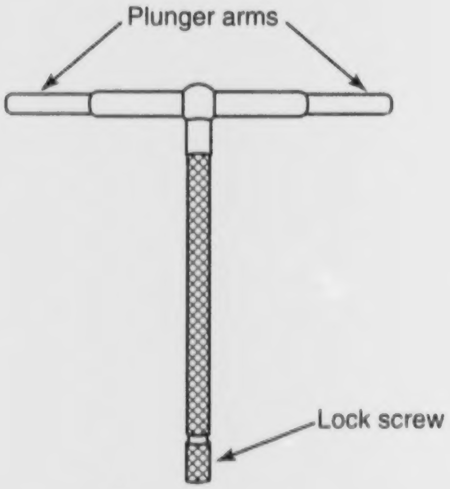
b. **Cylinder bore**—Used to check cylinder diameter, taper, and out-of-round; measurement is registered on dial

Figure 40



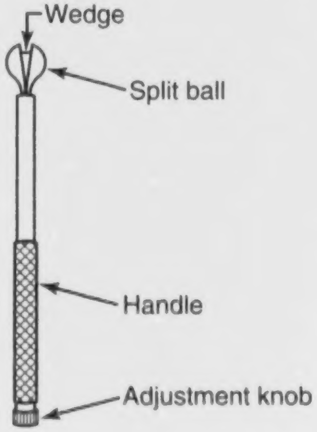
c. **Telescoping**—Used to measure the internal diameter or sizes of small cylinders, recesses, slots, and grooves; measurement is then read with an outside micrometer

Figure 41


Plunger arms
Lock screw

d. **Small hole**—Used to measure small holes and check valve guide wear; measurement is then read with outside micrometer

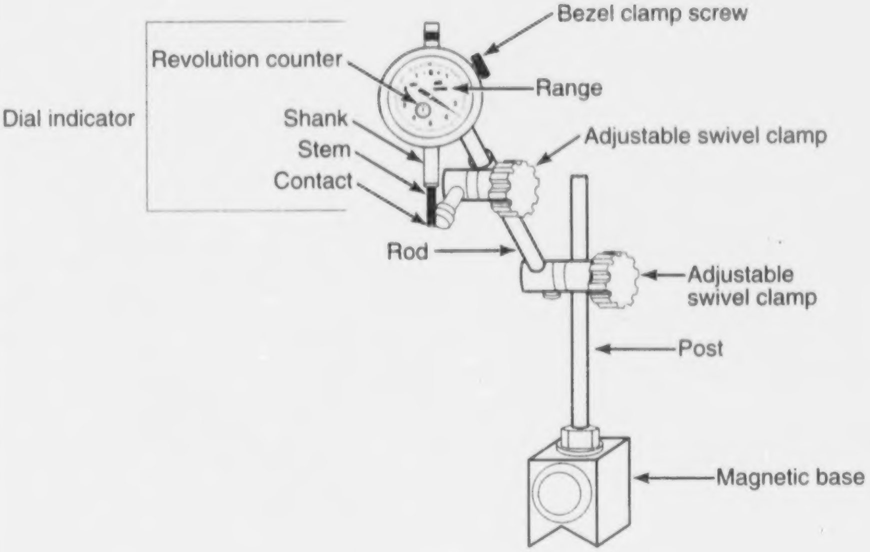
Figure 42


Wedge
Split ball
Handle
Adjustment knob

Objective 19

Parts of a dial indicator set

Figure 43

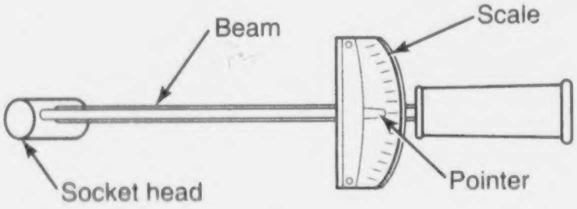

Bezel clamp screw
Revolution counter
Range
Dial indicator
Shank
Stem
Contact
Adjustable swivel clamp
Rod
Adjustable swivel clamp
Post
Magnetic base

Objective 20

Types of torque wrenches

a. **Beam or scale type**—Pointer moves to measure torque values

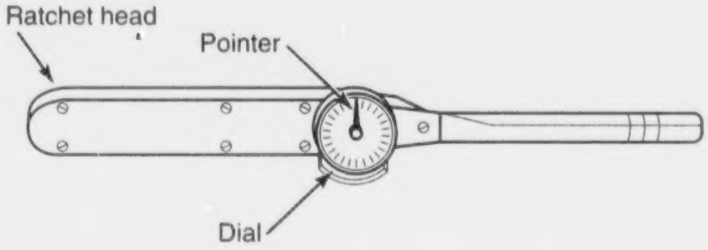
Figure 44


Beam
Scale
Socket head
Pointer

533

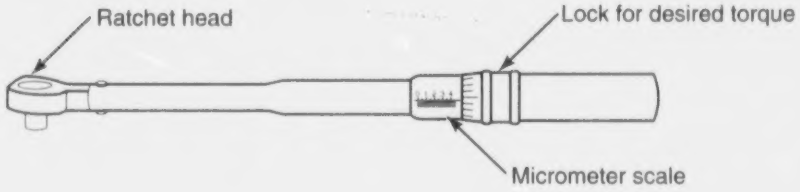
b. **Dial type**—Pointer on dial is used as indicator of desired torque; a memory pointer that indicates peak torque and a light signal are optional features

Figure 45



c. **Micrometer type (click)**—Specific torque is set, and then "click" that can be heard and felt will signal when that torque has been met

Figure 46



Note: Table top or bench torque testers are also available.

Objective 21

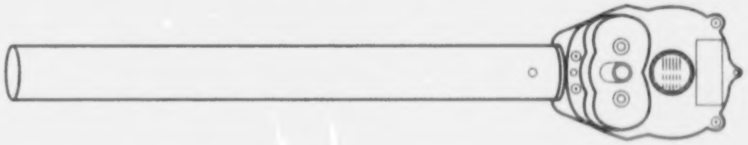
Use and care of torque wrenches

a. Torque wrenches are available in various sizes of drive ends—1/4", 3/8", 1/2", 3/4", and 1".

b. English and/or metric systems are used on most torque wrenches which measure torque in inch-pounds, foot-pounds, and/or Newton/meters.

c. A torque multiplier may be used with a torque wrench for high torque applications. Input is multiplied through the gearing.

Figure 47



d. Torque wrenches are delicate measuring instruments and must be handled with care. Store in case or box when not in use. Do not store them with other tools.

e. If a torque wrench is dropped, check it for accuracy before using it again.

f. Torque wrenches should be recalibrated every 6 months or more frequently depending on use. An out-of-calibration torque wrench can cause breakage of parts or tools.

g. Frequently inspect, clean, and lubricate ratchet mechanism with light machine oil.

h. Do not exceed rated torque.

i. Do not use to break fasteners loose.

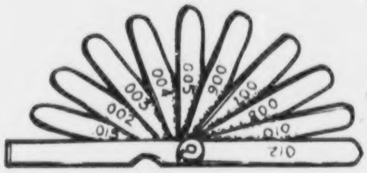
j. Do not force head of flex head against stops.

Objective 22

Types of feeler gauges

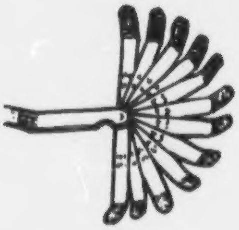
a. **Flat blades**—Set includes a variety of labeled thicknesses

Figure 48



b. **Bent blades**—Allow easier use in confined spaces such as when measuring for valve adjustments

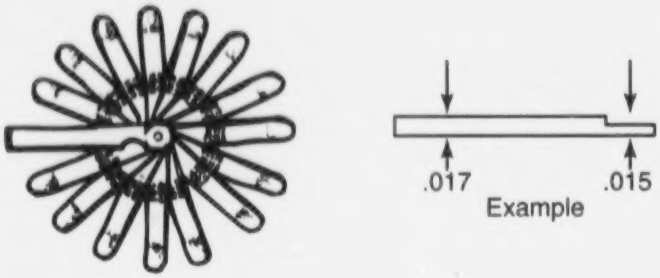
Figure 49



Note: When a thickness is called for that is between the prelabled blades of a feeler gauge set, blades of known thicknesses may be "stacked" on one another to achieve the proper thickness for measurement.

c. **Stepped or go-no-go blades**—Used to measure a predetermined maximum clearance

Figure 50



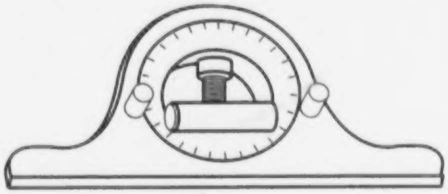
Example: When a 0.006 valve lash clearance is called for when an engine is at operating temperature but a clearance of more that 0.010 is excessive, a 0.006-0.010 stepped gauge would be used. 0.006″ would "go", but 0.010″ would not fit, therefore it would be a "no-go" fit.

Objective 23

Instruments used to measure angles

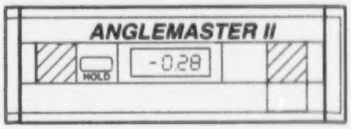
a. **Protractor**—Used for making measurements of angles; graduated in 180° in both directions

Figure 51



b. **Inclinometer**—Used for making precision digital measurements of angles from a horizontal axis (incline)

Figure 52



Objective 24

Assignment Sheet 1—Read U.S. Customary and Metric Rules

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Directions are followed	______
• Answers are correct	______

Basic Skills

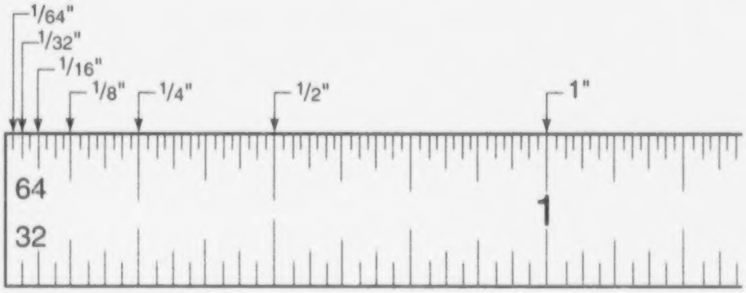
Reading Mathematics

Introduction

Reading fractional measurements on a U.S. customary rule

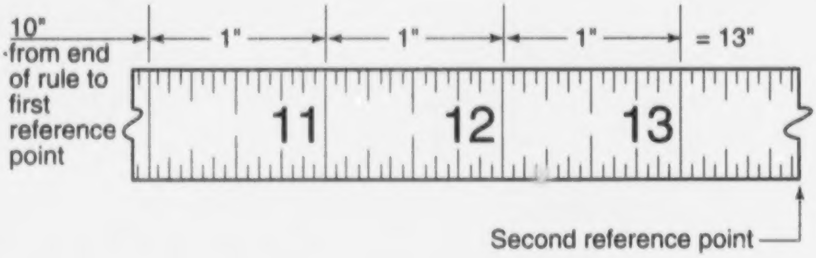
Note: All rules are read similarly. However, some rules are graduated with more divisions than others. The enlarged rule illustrated in Figure 1 is graduated in sixty-fourths of an inch on the top scale and third-seconds of an inch on the bottom scale. The staggered graduations are for halves, quarters, eighths, sixteenths, thirty-seconds, etc.

Figure 1



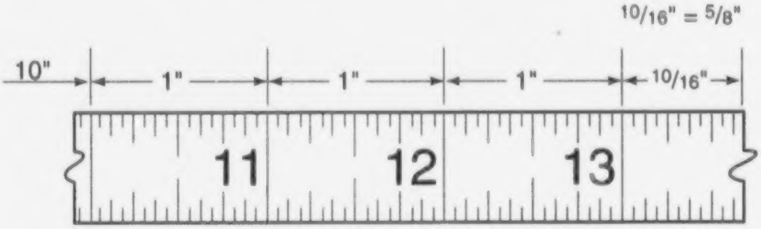
1. Align the end of the ruler with one reference point.
2. Determine the number of whole units between the end of the rule and the second reference point.

Figure 2


10" from end of rule to first reference point
1"
1"
1"
= 13"
11
12
13
Second reference point

3. Determine the number of fractional units between the last whole unit and the second reference point by counting the divisions.
4. Place this number over the rule scale (the rule in Figure 3 below is scaled in sixteenths of an inch) and reduce this fraction if possible.

Figure 3


10/16" = 5/8"
10"
1"
1"
1"
10/16"
11
12
13

5. Make a mixed fraction by adding this reduced fraction to the number of whole units counted earlier.

   Example: 13 inches + 5/8 inch = 13 5/8 inches

6. Convert measurements over 12 inches into feet and remaining inches.

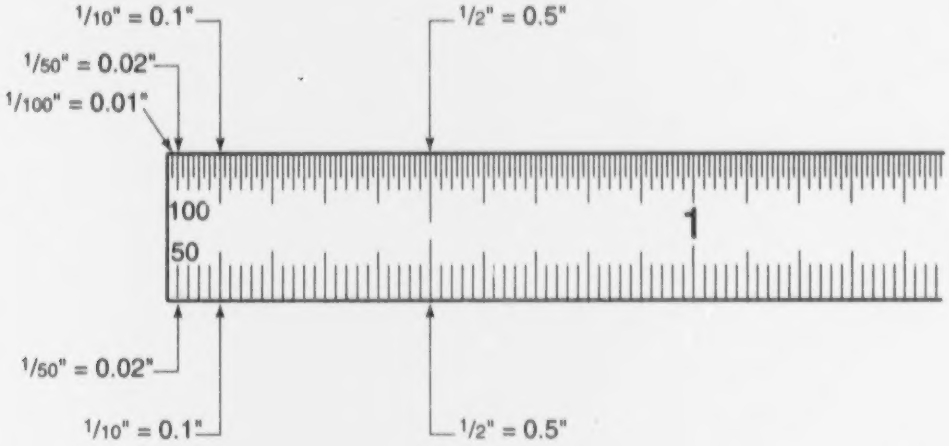
   Example: 13 5/8 ÷ 12 = 1´ 1 5/8˝

543

Reading decimal-inch measurements on a U.S. customary rule

Note: U.S. customary rules with decimal-inch increments allow for more precise measurements. The top scale on the enlarged rule illustrated in Figure 4 is graduated to one-hundredths of an inch (0.01 inch). The bottom scale is graduated in fiftieths of an inch (0.02 inch). The staggered graduations are for halves, tenths, and fiftieths.

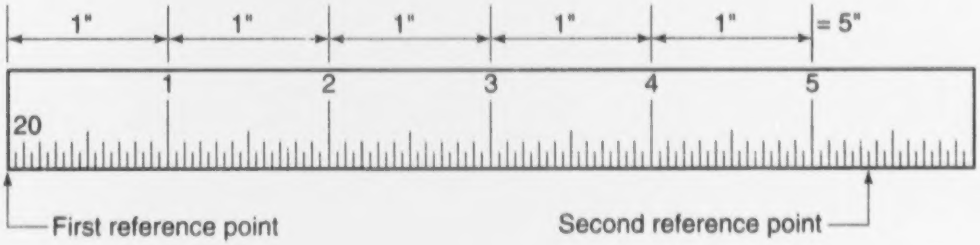
Figure 4


1/10" = 0.1"
1/2" = 0.5"
1/50" = 0.02"
1/100" = 0.01"
100
1
50
1/50" = 0.02"
1/10" = 0.1"
1/2" = 0.5"

1. Align the end of the rule with one reference point.
2. Determine the number of whole units between the end of the rule and the second reference point.

   Note: The rule illustrated in Figure 5 is graduated in twentieths of an inch.

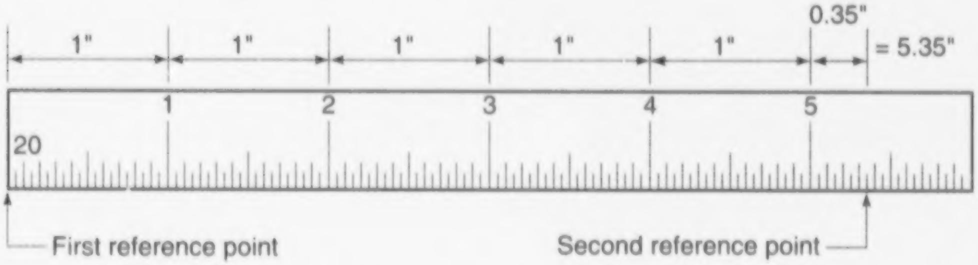
   Figure 5


1"
1"
1"
1"
1"
= 5"
1
2
3
4
5
20
First reference point
Second reference point

3. Count the number of graduations (twentieths, 0.05 inch) between the last whole unit and the second reference point.

4. Add this decimal fraction to the number of whole units counted earlier.

Figure 6


1"
1"
1"
1"
1"
0.35"
= 5.35"
1
2
3
4
5
20
First reference point
Second reference point

Reading a metric rule

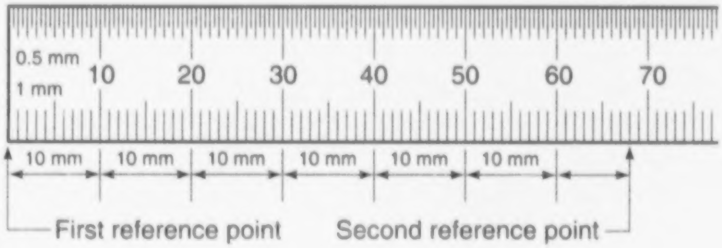
Note: Metric steel rules are available in a range from 150 millimeters to 1000 millimeters (1 meter) in length. The smallest graduation is 0.5 millimeter.

1. Align the end of the rule with one reference point.

2. Determine the number of whole units between the end of rule and the second reference point.

   Note: The enlarged metric rule illustrated in Figure 7 is graduated in half millimeters (0.5) on the top and whole millimeters (1 mm) on the bottom scale.

Figure 7

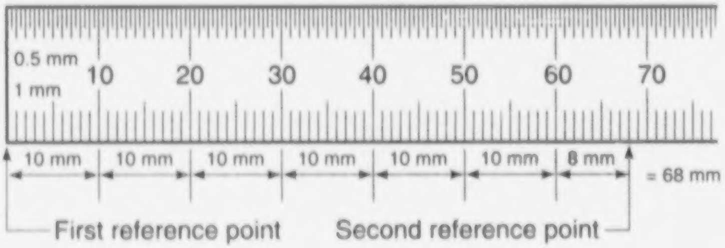

0.5 mm
1 mm
10
20
30
40
50
60
70
10 mm
10 mm
10 mm
10 mm
10 mm
10 mm
First reference point
Second reference point

545

3. Count the number of graduations (single and half millimeters) between the last whole number and the second reference point.

4. Add this number to the number of whole units counted earlier.

Figure 8


0.5 mm
1 mm
10
20
30
40
50
60
70
10 mm
10 mm
10 mm
10 mm
10 mm
10 mm
8 mm
= 68 mm
First reference point
Second reference point

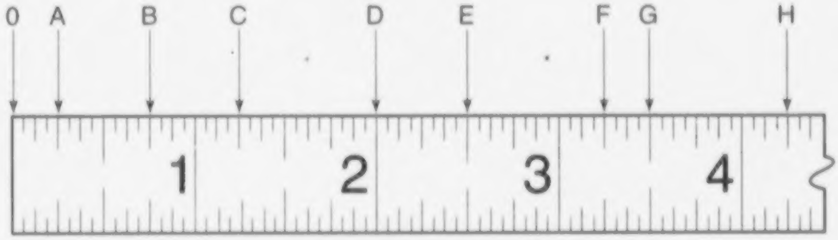
Directions

This assignment sheet is divided into three parts. Read each part, and then answer the questions in each part.

Part A

1. Read the U.S. customary rule illustrated below to the nearest quarter inch. Write your answers on the blanks provided.

Figure 9


0
A
B
C
D
E
F
G
H
1
2
3
4

a. 0 to A = ______ f. 0 to E = ______

b. A to B = ______ g. C to E = ______

c. 0 to C = ______ h. B to F = ______

d. A to D = ______ i. D to G = ______

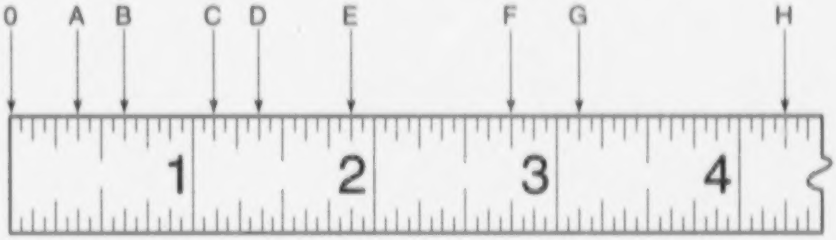
e. B to D = ______ j. A to H = ______

546

Assignment Sheet 1

2. Read the U.S. customary rule illustrated below to the nearest eighth inch. Write your answers on the blanks provided.

Figure 10



a. 0 to A = ______

b. A to B = ______

c. 0 to C = ______

d. B to D = ______

e. A to E = ______

f. 0 to F = ______

g. D to E = ______

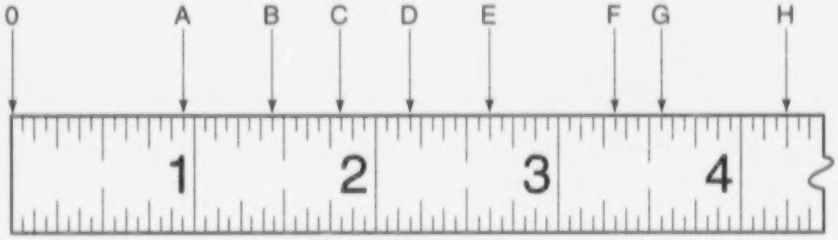
h. C to G = ______

i. 0 to H = ______

j. E to H = ______

3. Read the U.S. customary rule illustrated below to the nearest sixteenth inch. White your answers on the blanks provided.

Figure 11



a. 0 to A = ______

b. A to B = ______

c. 0 to C = ______

d. B to D = ______

e. A to E = ______

f. 0 to F = ______

g. C to F = ______

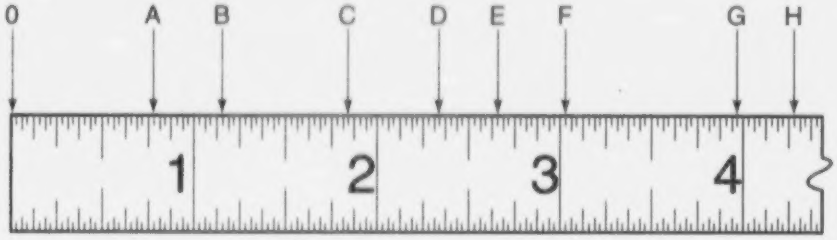
h. A to G = ______

i. 0 to H = ______

j. E to H = ______

4. Read the U.S. customary rule illustrated below to the nearest thirty-second of an inch. Write your answers on the blanks provided.

Figure 12



a. 0 to A = ______

b. 0 to B = ______

c. A to B = ______

d. 0 to D = ______

e. A to D = ______

f. B to E = ______

g. C to F = ______

h. B to G = ______

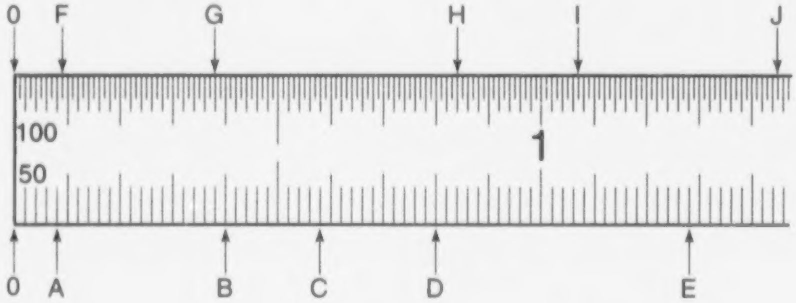
i. 0 to H = ______

j. D to H = ______

Part B

1. Read the U.S. customary rule with decimal graduations in fiftieths and hundredths. Write your answers on the blanks provided.

Figure 13



a. 0 to A = ______

b. 0 to B = ______

c. 0 to C = ______

d. 0 to D = ______

e. 0 to E = ______

f. 0 to F = ______

g. 0 to G = ______

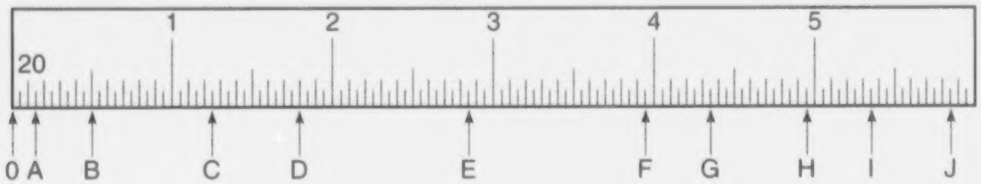
h. 0 to H = ______

i. 0 to I = ______

j. 0 to J = ______

2. Read the U.S. customary rule with decimal graduations in twentieths shown below. Write your answers on the blanks provided.

Figure 14


1
2
3
4
5
20
0
A
B
C
D
E
F
G
H
I
J

a. 0 to A = ______

b. 0 to B = ______

c. 0 to C = ______

d. 0 to D = ______

e. 0 to E = ______

f. 0 to F = ______

g. 0 to G = ______

h. 0 to H = ______

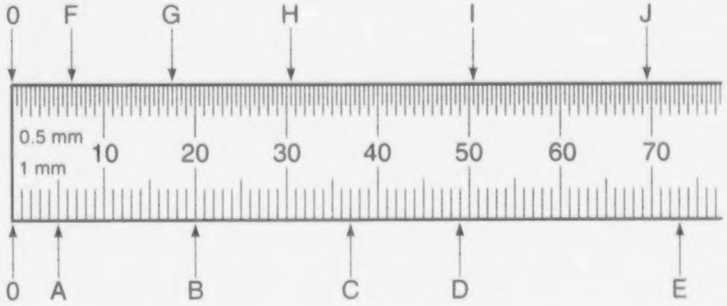
i. 0 to I = ______

j. 0 to J = ______

Part C

1. Read the enlarged metric rule with 1-millimeter and 0.5 millimeter graduations shown below. Write your answers on the blanks provided.

Figure 15


0
F
G
H
I
J
0.5 mm
1 mm
10
20
30
40
50
60
70
0
A
B
C
D
E

a. 0 to A = ______

b. 0 to B = ______

c. 0 to C = ______

d. 0 to D = ______

e. 0 to E = ______

f. 0 to F = ______

g. 0 to G = ______

h. 0 to H = ______

i. 0 to I = ______

j. 0 to J = ______

Objective 25

Assignment Sheet 2—Draw Lines to Specified Lengths

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Directions are followed	______
• Line lengths are correct	______

Basic Skills

Reading Mathematics

Materials List

- Steel rule
- Pen or pencil
- Sheet of paper (unlined)

Directions

With a steel rule and a pen or pencil, draw straight lines of the following lengths on a bank sheet of paper:

1. 2 1/4 inches
2. 3 3/4 inches
3. 4 1/2 inches
4. 1 1/8 inches
5. 2 5/8 inches
6. 4 3/8 inches
7. 5 7/8 inches
8. 2 1/16 inches
9. 4 5/16 inches
10. 5 9/16 inches
11. 3 15/16 inches
12. 5 7/32 inches
13. 1/ 19/32 inches
14. 2 1/64 inches
15. 1 9/64 inches
16. 3 3/64 inches
17. 4 47/64 inches
18.. 4 31/32 inches

Objective 26

Assignment Sheet 3—Measure Lines Using a Steel Rule

Name ______________ Overall Rating ______

Date ______________

Evaluation Criteria	Rating
• Directions are followed	______
• Measurements are correct	______

Basic Skills

Reading Mathematics

Materials List

- Steel rule
- Pen or pencil

Directions

Using a correctly graduated scale or rule, measure the following lines to the specified graduations. Reduce measures to the lowest terms (i.e. 16/64″ = 1/4″) and write correct answers on the lines.

1. Measure these lines to the nearest quarter of an inch.

a. ______________________________

b. ____

c. _________

d. __________________

2. Measure these lines to the nearest eighth of an inch.

a. ____

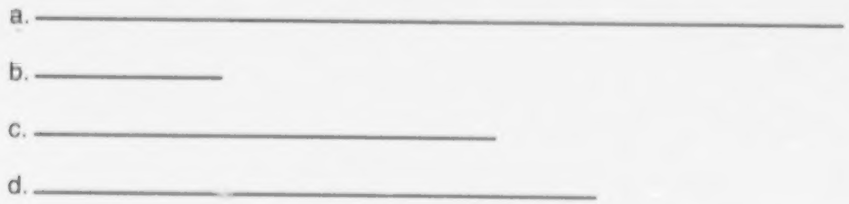
b. _______________________

c. __________________________________

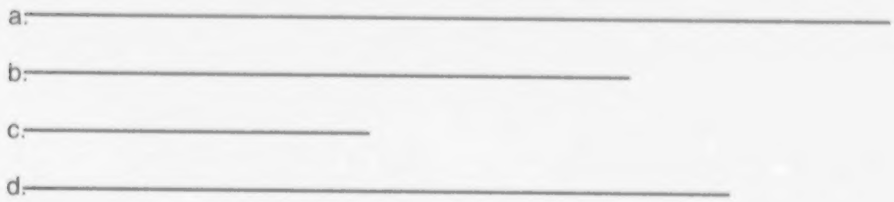
d. _______________________________________

Assignment Sheet 3

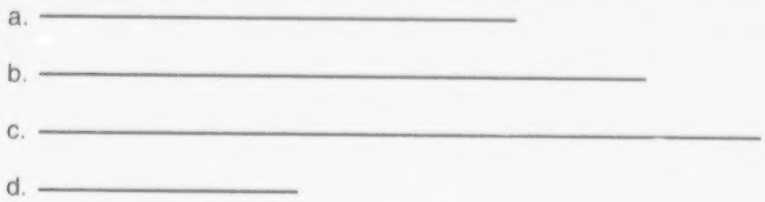
3. Measure these lines to the nearest sixteenth of an inch.



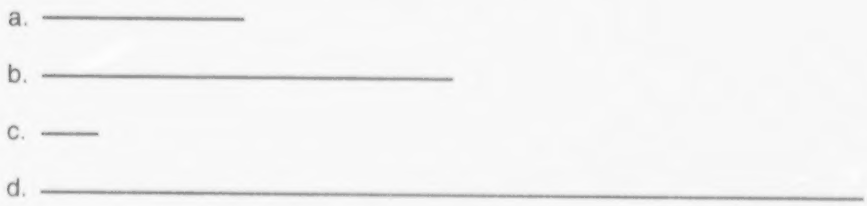
4. Measure these lines to the nearest thirty-second of an inch.



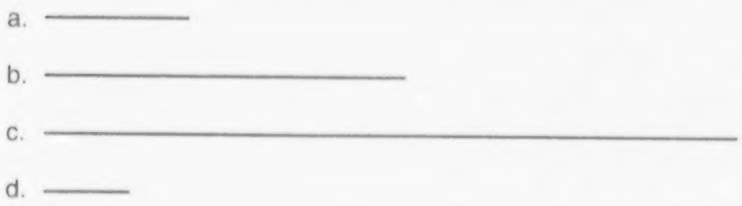
5. Measure these lines to the nearest sixty-fourth of an inch.



6. Measure these lines to the nearest centimeter.



7. Measure these lines to the nearest millimeter.



Objective 27

Assignment Sheet 4—Measure Lines on Objects

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	_____
• Measurements are correct	_____

Basic Skills

Reading Mathematics

Materials List

- Steel rule
- Pen or pencil

Directions

Use a steel rule to measure each lettered dimension on the following objects. Use the finest graduation (32nds or 64ths) on the rule and reduce measure to the lowest terms (i.e., 16/64″ = 1/4″). Indicate each individual measurement (in lowest terms) in the correct answer space.

Answers

1. a. _____

b. _____

c. _____

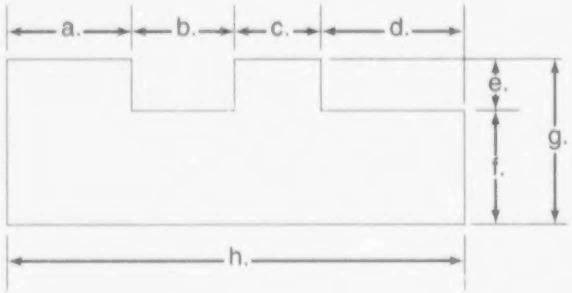
d. _____

e. _____

f. _____

g. _____

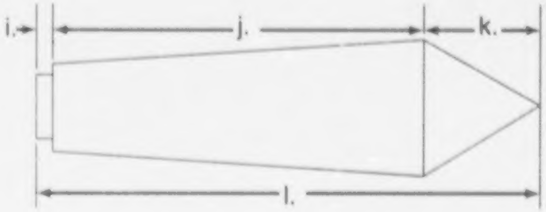
h. _____



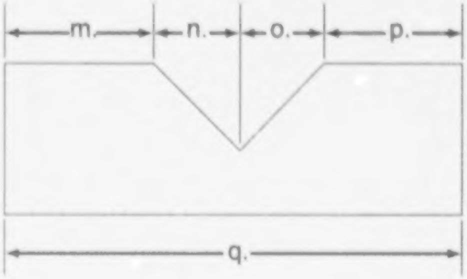
Assignment Sheet 4

Answers

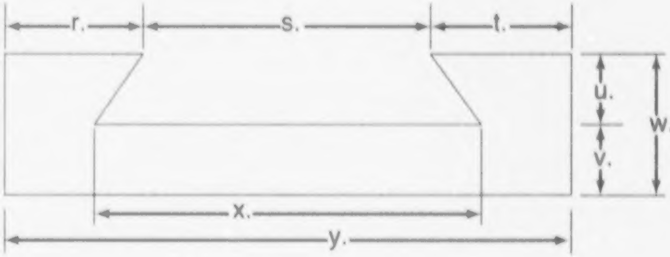
2. i. _____
   j. _____
   k. _____
   l. _____



3. m. _____
   n. _____
   o. _____
   p. _____
   q. _____



4. r. _____
   s. _____
   t. _____
   u. _____
   v. _____
   w. _____
   x. _____
   y. _____



554

Objective 28

Assignment Sheet 5—Measure Circle Diameters

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Measurements are correct	______

Basic Skills

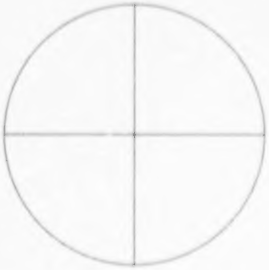
Reading Mathematics

Materials List

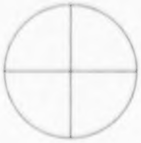
- Steel rule
- Pen or pencil

Directions

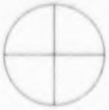
Use a rule to measure each given circle. Use the finest graduation on the rule (32nds or 64ths) and reduce the dimensions to lowest terms (i.e., 16/64" = 1/4"). Make certain that the true diameter of the circle is measured by measuring along the axis line. Indicate the correct dimension in the space provided.



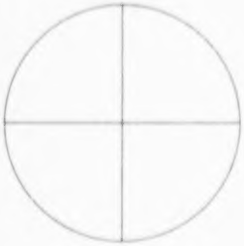
1. __________



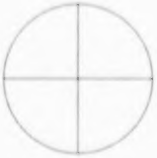
2. __________



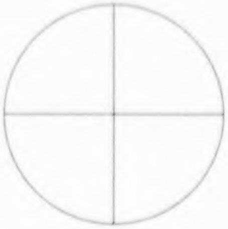
3. __________



4. __________

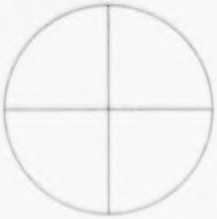


5. __________

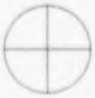


6. __________

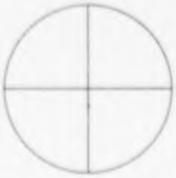
Assignment Sheet 5



7. ________



8. ________



9. ________

Objective 29

Assignment Sheet 6—Read Standard and Metric Micrometers

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

Basic Skills

Reading Mathematics

Introduction

Reading outside micrometers

Outside micrometers come in a variety of sizes. Each one is used to measure only a particular range, so you must be sure to choose the proper size. Micrometer sizes 0 to 1 inch, 1 to 2 inches, 2 to 3 inches, and 4 to 5 inches are commonly used. Regardless of the construction or size, the micrometer principle remains the same: The total measurement is equal to the sum of the reading on the thimble and sleeve.

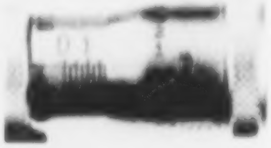
If you have a standard micrometer available, refer to it while you read the following information, which explains how to read a micrometer.

1. Note the number of the last vertical line visible on the sleeve (each numbered line on the sleeve represents a .100-inch increment).
2. Add .025 inch for each additional line that shows on the sleeve.
3. Add to this figure the number of the graduation on the thimble (there are 25 lines on the thimble, each equal to 0.001 inch).
4. Read the required reading as the sum of all additions; see the examples in Figure 1.

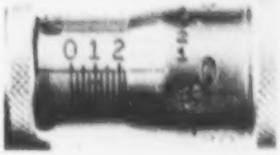
Assignment Sheet 6

Figure 1

a. .000
b. .075
c. +.000
d. .075"

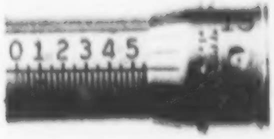


a. .100
b. .075
c. +.000
d. .175"

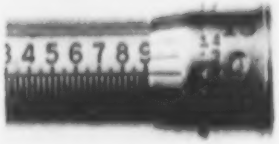


a. .200
b. .025
c. +.000
d. .225"

a. .000
b. .025
c. +.012
d. .037"



a. .500
b. .050
c. +.012
d. .562"



a. .900
b. .000
c. +.012
d. .912"

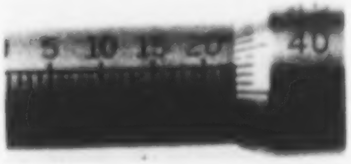
Reading metric micrometers

Metric micrometer sizes 0 to 25 millimeters, 25 to 50 millimeters, and 50 to 75 millimeters are commonly used. Metric micrometers are read in the same manner as standard micrometers. The metric micrometer is graduated to read to an accuracy of 0.01 millimeter (equivalent to 0.0004 inch).

If you have a metric micrometer available, refer to it while you read the following information, which explains how to read a metric micrometer.

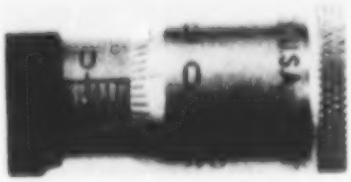
1. Note the number on the last vertical line visible on the sleeve (each numbered line on the sleeve represents a 5-millimeter increment).
2. Add 1 millimeter for each additional line that shows on top of the sleeve above the index line.
3. Add 0.5 millimeter for each additional line that shows on the bottom of the sleeve below the index line.
4. Add the number of graduations on the thimble (there are 50 lines on the thimble, each equal to 0.01 millimeter).
5. Read the required reading as the sum of all additions. See the examples in Figure 2.

Figure 2



a. 20.0
b. 2.0
c. 0.5
d. +0.38
22.88mm

a. 0.0
b. 1.0
c. 0.0
d. +0.34
1.34mm



a. 0.0
b. 4.0
c. 0.0
d. +0.0
4.0mm

a. 5.0
b. 0.0
c. 0.5
d. +0.19
5.69mm

Reading inside micrometers (metric and customary)

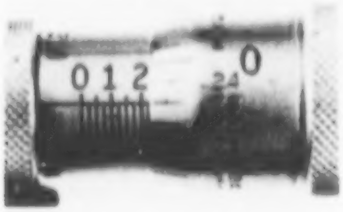
The inside micrometer is read in exactly the same way as the outside micrometer. However, most inside micrometers have only .500 travel; a spacer of .500 is used to cover the remainder of the inch. Anything over 1 inch requires the use of extension rods.

Directions

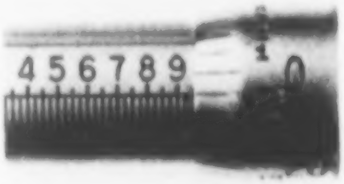
Part A

Read the settings on the following U.S. customary micrometers graduated in 0.001 inch. Write your answers on the blanks.

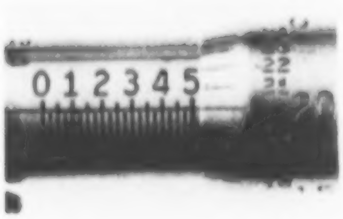
______ 1.



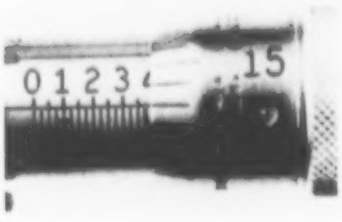
______ 2.



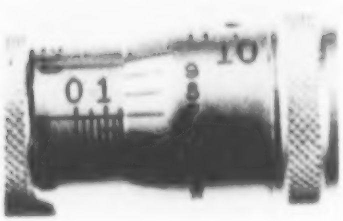
______ 3.


0 1 2 3 4 5
22
21

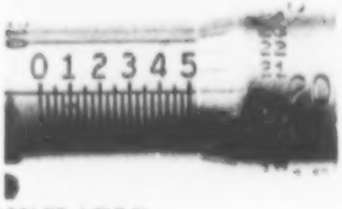
______ 4.



______ 5.

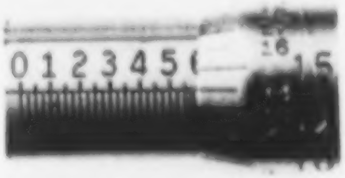


______ 6.

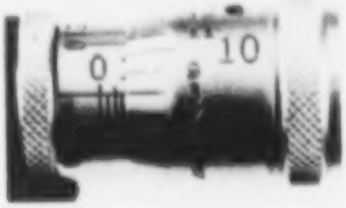

0 1 2 3 4 5
22
21

BEST COPY AVAILABLE

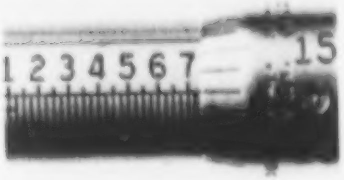
______ 7.



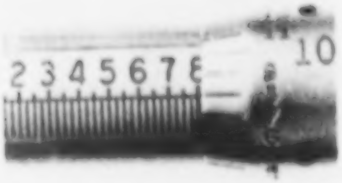
______ 8.



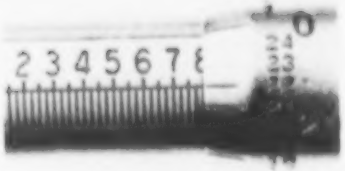
______ 9.



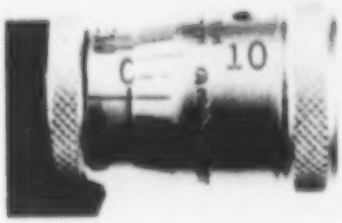
______ 10.



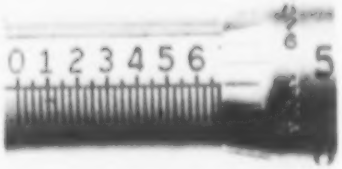
______ 11.



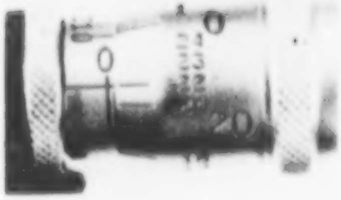
______ 12.



______ 13.



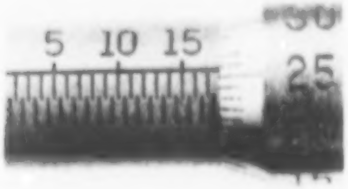
______ 14.



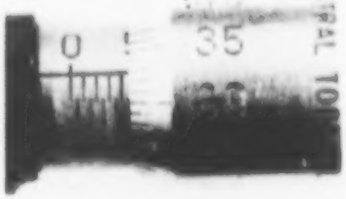
Directions **Part B**

Read the settings on the following metric micrometers graduated in 0.01 mm. Write your answers in the blanks.

______ 1.

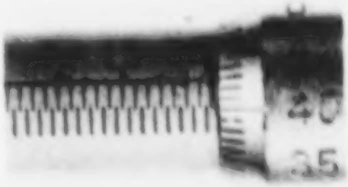


______ 2.

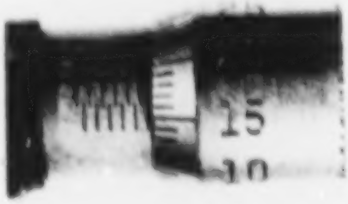


BEST COPY AVAILABLE

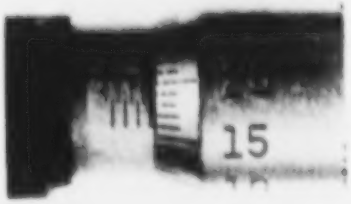
______ 3.



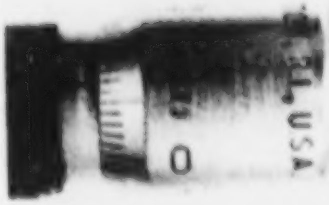
______ 4.



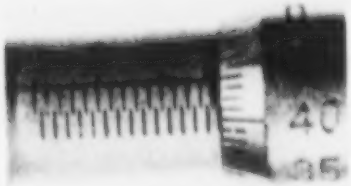
______ 5.



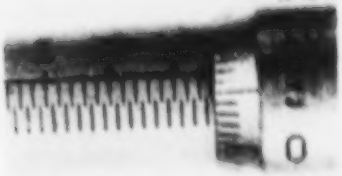
______ 6.



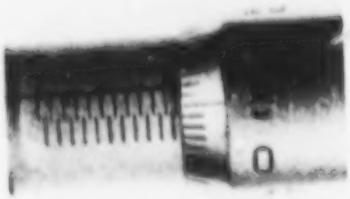
______ 7.



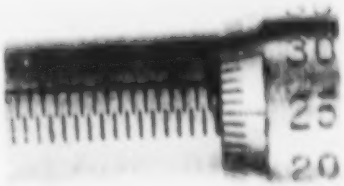
______ 8.



______ 9.



______ 10.



BEST COPY AVAILABLE

Objective 30

Job Sheet 1—Use a Dial Caliper

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed correct procedure for using dial caliper	______
• Consistently obtained correct dial-caliper reading	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Standard or metric dial caliper
- Dial caliper manufacturer's instructions
- Pencil and paper for recording readings
- Lint-free cloth and light machine oil
- Components to be measured (selected by instructor)

Procedure

☐ 1. Apply light machine oil to lint-free cloth and gently clean dial caliper.

☐ 2. Follow manufacturer's instructions for adjusting movable jaw on dial caliper until jaws are closed. Set dial to zero.

☐ 3. Check component to be measured to be sure that it is free of nicks, burrs, and dents.

☐ 4. Open caliper jaws to a distance slightly greater than the thickness of the component to be measured.

☐ 5. Place the fixed caliper jaw on the component to be measured.

☐ 6. Slide the movable jaw until it also contacts component to be measured.

☐ 7. Tighten (but do not overtighten) clamp screws and fine adjustment nut as necessary.

☐ 8. Carefully remove the caliper from the component to be measured.

☐ 9. Read caliper dial.

☐ 10. Record reading.

☐ 11. Repeat process until all components have been measured and measurements have been recorded.

☐ 12. Clean dial caliper with a lint-free cloth, and return caliper to its proper storage, leaving a gap between the fixed and movable jaws to allow for the expansion and contraction of the metal in the caliper.

☐ 13. Clean work area and return tools and equipment to proper storage.

☐ 14. Hand in recorded measurements to your instructor for evaluation.

Evaluator's Comments: ______________________________

____

____

Objective 31

Job Sheet 2—Use an Outside Micrometer

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed correct procedure	______
• Consistently obtained correct micrometer reading	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Standard or metric outside micrometer
- Micrometer manufacturer's instructions
- Pencil and paper for recording readings
- Lint-free cloth and light machine oil
- Piece of line or known dimensions to check outside micrometer reading
- Steel rule
- Components to be measured (selected by instructor)

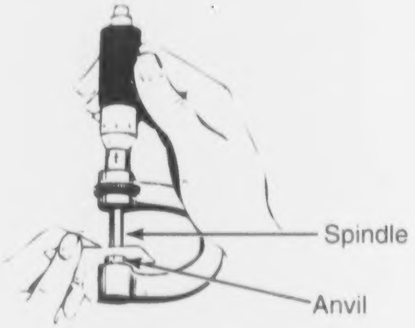
Procedure

☐ 1. Select correct size of micrometer for component you will be measuring.

☐ 2. Check component to be measured to be sure that it is free of nicks, burrs, and dents.

☐ 3. Apply light machine oil to lint-free cloth and gently clean micrometer spindle and anvil.

Figure 1

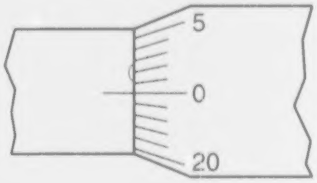


☐ 4. Check micrometer at zero reference.

  a. Rotate thimble until spindle just touches anvil, and then turn ratchet until several clicks are heard.

  b. Check to see that reference line on sleeve and zero on thimble match up.

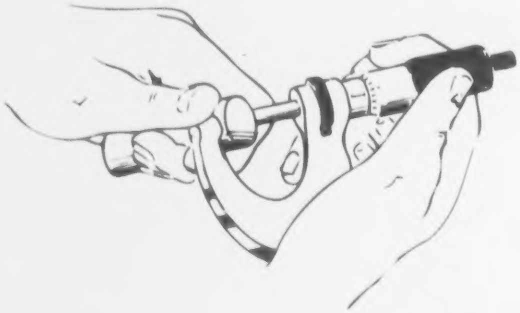
  Figure 2



☐ 5. Hold micrometer according to type of component being measured.

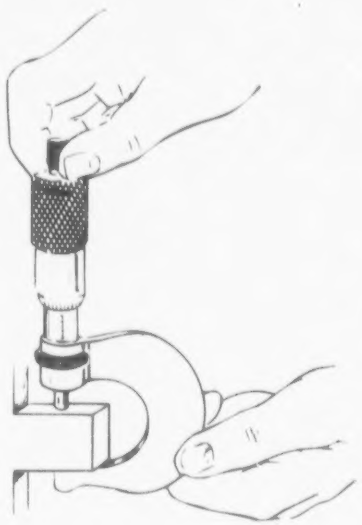
  a. To measure a nonstationary object, hold micrometer in one hand and component in other as show in Figure 3.

  Figure 3



b. To measure a stationary object, hold micrometer in both hands as shown in Figure 4.

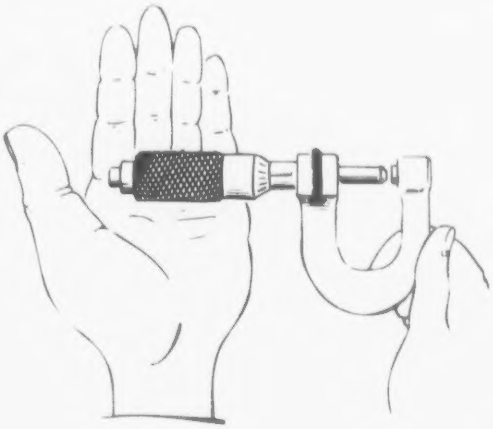
Figure 4



☐ 6. Before measuring a component selected by the instructor, check the accuracy of the micrometer by measuring the outside diameter of a piece of line that has a standard dimension. If the micrometer reading and the standard dimension are not the same, test and use another micrometer.

☐ 7. Roll micrometer along palm of hand or forearm for quick adjustment (see Figure 5), and then place directly over center of component to be measured.

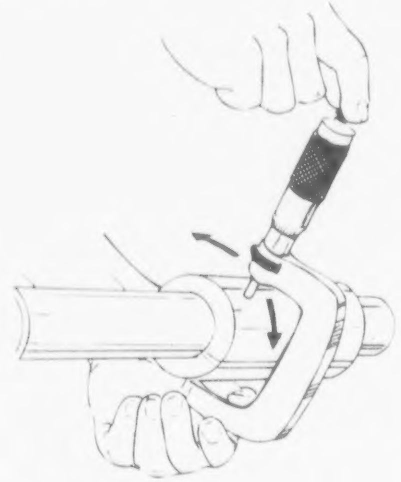
Figure 5



☐ 8. Twist thimble between your thumb and first finger, stopping when spindle just touches component to be measured.

☐ 9. Hold anvil steady and move spindle gently over component to locate true center line.

Figure 6



☐ 10. If micrometer has a ratchet stop to adjust tightness, turn it until you hear at least two clicks.

☐ 11. Take reading while component is still in micrometer. If this is not possible, use locknut to lock spindle at correct reading, then carefully remove micrometer from component and read measurement.

☐ 12. Repeat this process until all components have been measured and measurements have been recorded.

☐ 13. Clean micrometer with a lint-free cloth and return micrometer to its proper storage, leaving the spindle and anvil open for storage.

☐ 14. Clean work area and return tools and equipment to proper storage.

☐ 15. Hand in recorded measurements to your instructor for evaluation.

Evaluator's Comments: ______________________________

____

____

Objective 32

Job Sheet 3—Use an Inside Micrometer

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed correct procedure for using inside micrometer	______
• Consistently obtained correct inside micrometer reading	______

Basic Skills

Reading · Mathematics · Critical Thinking · Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Standard or metric inside micrometer
- Micrometer manufacturer's instructions
- Pencil and paper for recording readings
- Lint-free cloth and light machine oil
- Component of standard dimension to check inside micrometer reading
- Steel rule
- Components to be measured (selected by instructor)

Procedure

☐ 1. Check component to be measured to be sure that it is free of nicks, burrs, or dents.

☐ 2. Apply light machine oil to a lint-free cloth and gently clean anvil and spindle/rod contact points and micrometer accessories.

☐ 3. Check micrometer at zero reference to be sure that reference line on sleeve and zero on thimble match.

☐ 4. Use a steel rule to measure approximate inside diameter of component to be measured.

☐ 5. *If* necessary, select correct extension rod and collar for required measurement.

☐ 6. *If* necessary, select extension collar to utilize full range of extension rod.

☐ 7. *If* necessary, select extension handle for small-hole or deep-hole application.

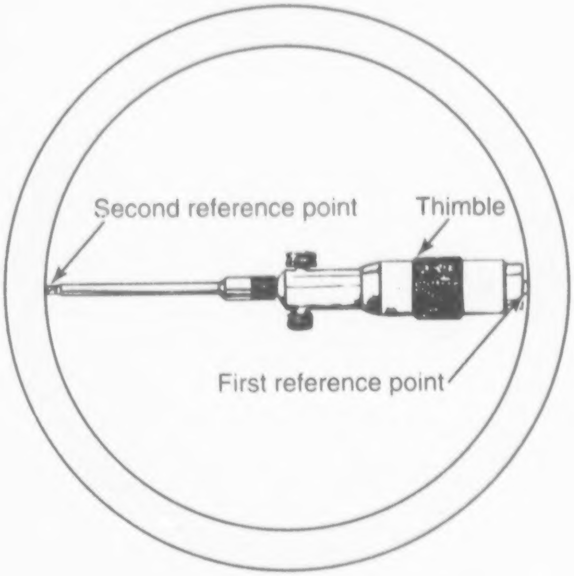
☐ 8. Follow micrometer manufacturer's instructions and use proper tools to assemble accessories on micrometer.

☐ 9. Before measuring a component selected by the instructor, check the accuracy of the micrometer by measuring the inside diameter of a component that has a standard dimension. *If* the micrometer reading and the standard dimension are **not** the same, test and use another micrometer.

☐ 10. Place micrometer inside component to be measured, and establish reference point for spindle contact point. (Figure 1)

☐ 11. While holding micrometer steady with spindle contact point on reference point, rotate thimble until anvil contact point just touches component wall to establish second reference point.

Figure 1



☐ 12. Move spindle contact point from side to side to find true inside diameter of component.

☐ 13. *If* possible, read micrometer while inside component. *If* this is **not** possible, the micrometer locks automatically and may be withdrawn from component for reading.

☐ 14. Read micrometer. Add to this reading the length of extension rod and collar if used.

☐ 15. Repeat this process until all components have been measured and measurements have been recorded.

☐ 16. Disassemble accessories from micrometer, if necessary. Clean micrometer with soft, lint-free cloth and place in proper storage.

☐ 17. Clean work area and return equipment and materials to proper storage.

☐ 18. Hand in recorded measurements to your instructor for evaluation.

Evaluator's Comments: ______________________________

____

____

Objective 33

Job Sheet 4—Use Telescoping Gauges

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Selected correct gauges	______
• Followed correct procedure for using telescoping gauges	______
• Obtained correct readings	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Telescoping gauge set
- Outside micrometer or dial caliper
- Pencil and paper for recording readings
- Components to be measured (selected by instructor)

Procedure

☐ 1. Select the correct-sized telescoping gauge for the component you are measuring.

☐ 2. Compress the gauge plunger arms until the gauge is slightly smaller than the internal diameter of the component to be measured, and then tighten the lockscrew to lock the plunger arms in that position.

Note: Do not overtighten the lockscrew.

☐ 3. Insert the telescoping gauge into the component, and loosen the lockscrew to allow the plunger arms to extend out to fit the inside diameter of the component.

☐ 4. Check to make certain the plunger arms are at right angles to the component walls so that the measurement will be accurate.

☐ 5. When the plunger arms are properly aligned, tighten the lockscrew to lock the plunger arms in position.

Note: Do not overtighten the lockscrew.

☐ 6. Test for exact internal diameter by rotating the gauge against the component walls. *If* the gauge sticks or does not remain against the component walls throughout the rotation, repeat steps above to refit the gauge.

☐ 7. Using a sweeping motion, remove the gauge from the component.

☐ 8. Measure the length of the plunger arms with a micrometer or a dial caliper (see Job Sheets 1-3). Record reading.

☐ 9. Repeat process on remaining components until all components have been measured and measurements have been recorded.

☐ 10. Clean telescoping gauges and return to proper storage.

☐ 11. Clean work area and return tools and equipment to proper storage.

☐ 12. Hand in the recorded measurements to your instructor for evaluation.

Evaluator's Comments: ______________________________

____

____

572

Objective 34

Job Sheet 5—Use a Dial Indicator

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed correct procedure for using dial indicator	______
• Consistently obtained correct dial-indicator readings	______

Basic Skills

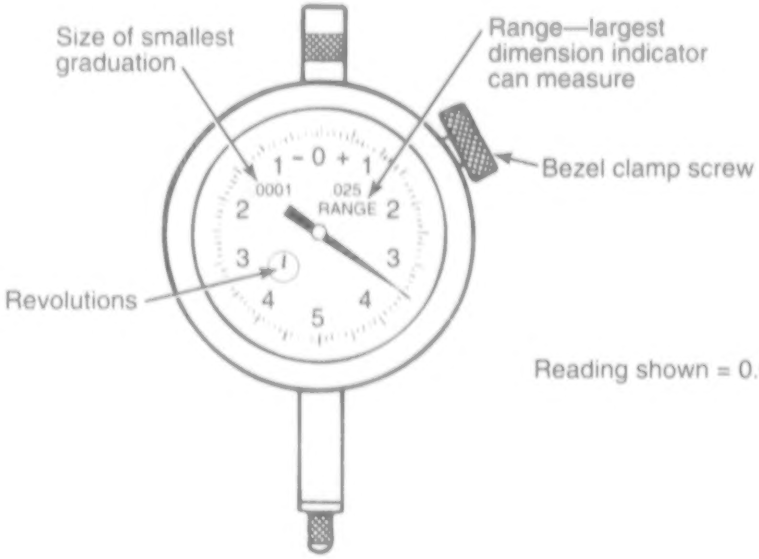
Reading Mathematics Critical Thinking Technology

Introduction

Guidelines for reading a dial indicator

1. To make a reading, check the size of the smallest graduation and count. The numbered graduations are usually thousandths. Thus, the reading on the dial indicator in Figure 1 is 0.0031 inch. Had the pointer been pointing to the same graduation on the left side of the indicator, the reading would have been –0.0031 inch.

Figure 1


Size of smallest graduation
Range—largest dimension indicator can measure
Bezel clamp screw
Revolutions
1 − 0 + 1
.0001
.025 RANGE
2
3
4
5
4
3
2
1

Reading shown = 0.0031"

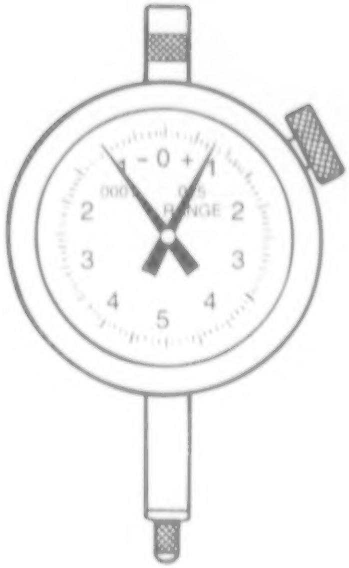
2. Most indicators may be read with the pointer moving either left or right (– or +).

3. On some indicators, the pointer can go around several times. To keep track of the readings, you must count the revolutions of the pointer. Some models have a revolution counter for this purpose.

4. The bezel and dial may be rotated to set the zero on the dial under the pointer in any position. The bezel clamp screw then holds the new position.

5. For some dial indicator uses, you must measure what is called *total (or full) runout*. This occurs when the pointer moves both in the plus and minus directions. To get total dial indicator runout, you must add the readings in both directions. An example is shown in Figure 2 below. The total runout is .10 mm plus .08 mm, which equals .18 millimeters.

Figure 2



Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Dial indicator
- Dial indicator clamps, rods, and post
- Base on which to mount dial indicator
- Pencil and paper for recording readings
- Eye protection
- Components to be measured (selected by instructor)

Procedure

☐ 1. Check component to be measured to be sure that it is clean and free of burrs, nicks, or dents.

☐ 2. Assemble dial indicator set using clamps, rods, and post on base.

☐ 3. Secure assembled dial indicator set on base to work surface.

☐ 4. Adjust clamps so that dial indicator stem contacts component to be measured.

☐ 5. Adjust clamps so that plunger is depressed two revolutions of pointer, and then tighten clamps.

☐ 6. Rotate bezel until zero mark is in line with end of pointer.

☐ 7. Measure component. Check the size of the smallest graduation and count.

☐ 8. Record measurement. Note + or – on measurement.

☐ 9. Repeat steps 4 through 8 until all components have been measured and measurements have been recorded.

☐ 10. Disassemble dial indicator set. Return to proper storage.

☐ 11. Hand in the recorded measurements to your instructor for evaluation.

Evaluator's Comments: ____________________

____

____

Objective 35

Job Sheet 6—Check a Torque Wrench for Accuracy

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	____
• Set up test properly	____
• Calculated torque correctly	____
• Demonstrated quality work throughout	____

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

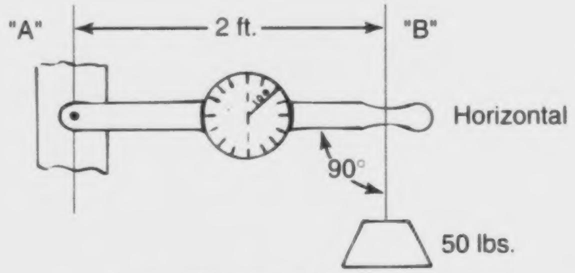
Tools, Equipment, and Materials

- Torque wrench
- Vise
- "Known" weight
- Strong cord

Procedure

☐ 1. Hang torque wrench on a fixed nut or secure in a vise.

Figure 1



A = Center line of nut
B = Point of suspension

☐ 2. Set the indicator to "0".

☐ 3. Hang a known weight from the wrench handle at any known distance from the center of the nut (Figure 1).

☐ 4. Multiply the weight times the distance from A to B (Figure 1).

☐ 5. Compare the answer to the indicator reading.

Example: In Figure 1, 50 pounds x 2 feet = 100 foot pounds

Note: Torque wrenches that fail this accuracy test will need to be recalibrated. Most tool manufacturers provide calibration service.

☐ 6. Check with your instructor on what to do with faulty torque wrenches.

☐ 7. Return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 36

Job Sheet 7—Use a Small Hole Gauge to Measure Valve Guide Diameter

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Selected correct gauge	______
• Followed correct procedure for using gauge	______
• Obtained correct readings	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

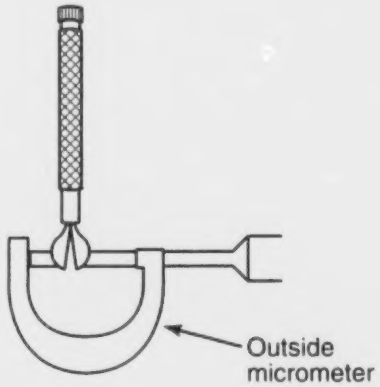
Tools, Equipment, and Materials

- Small hole gauge set
- Outside micrometer or dial caliper
- Engine head with valve guides to be measured
- Pencil and paper for recording readings

Procedure

☐ 1. Select correct size small hole gauge and insert into valve guide to be measured.

Figure 1



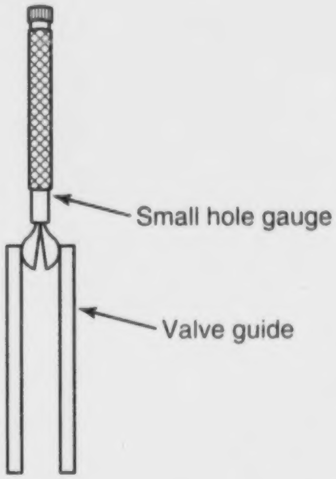
☐ 2. Position gauge at either top, middle, or bottom of the guide and tighten tension knob until a slight drag is felt on the gauge as you move it in the guide.

☐ 3. If the measurement is being made at the top or middle of the guide, withdraw the gauge out the top of the guide. If measurement is being made at the bottom, push gauge out the bottom.

Caution: Do not overtighten the tension knob. Damage could result.

☐ 4. Using an outside micrometer or dial caliper, measure diameter of the split ball and record your reading.

Figure 2



☐ 5. Repeat the process for the other positions of the guide. Then measure the other guides assigned to you and record these measurements.

☐ 6. Clean the small hole gauge and micrometer and return to proper storage.

☐ 7. Clean work area and return all remaining tools and materials to proper storage.

☐ 8. Hand in recorded measurements to your instructor for evaluation.

Evaluator's Comments: ______________________________

____

____

Objective 37

Job Sheet 8—Use a Cylinder Bore Gauge

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Set up cylinder bore gauge correctly	______
• Followed correct procedures for using gauge	______
• Obtained correct readings	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Cylinder bore gauge
- Engine block
- Pencil and paper for recording readings

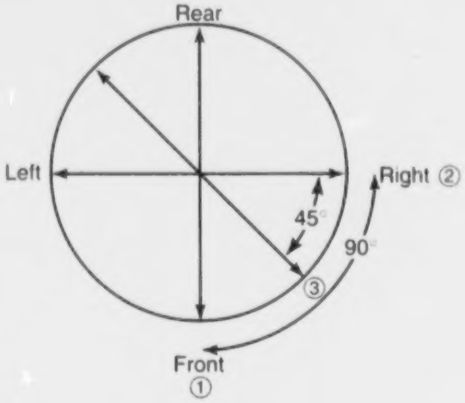
Procedure

☐ 1. Set up gauge to obtain a reading on the dial in the cylinder near the top below the ridge.

Note: Like an inside micrometer, the gauge must be rocked back and forth in the cylinder to obtain a correct measurement.

☐ 2. Position the gauge so that it is lined up with the front and back of the engine. Record the reading.

Figure 1



☐ 3. Turn the gauge 90° and record the reading.

☐ 4. Rotate the gauge an additional 45° and record this reading.

☐ 5. The difference between the largest and smallest diameters is that cylinder's out-of-roundness at the top of the cylinder. Record this reading.

☐ 6. Make three similar measurements at the bottom of the cylinder to obtain the out-of-roundness at the bottom of the cylinder. Record these readings.

☐ 7. Subtract the bottom out-of-roundness reading from the top reading to obtain cylinder taper. Record this reading.

☐ 8. Clean the gauge and return to proper storage.

☐ 9. Clean work area and return material to proper storage.

☐ 10. Hand in recorded measurements to your instructor for evaluation.

Evaluator's Comments: ______________________________

____

____

Unit Contents

Student Components

Student Page

Objective Sheet 5A–3
Information Sheet 5A–5

Assignment Sheet

1—Complete a Job Ticket 5A–13

Job Sheet

1—Use a Computer System to Obtain Parts Information 5A–15

Objective Sheet

Unit Objective

After completing this unit, the student should be able to complete a job ticket and to use a computer system to obtain parts information. The student should demonstrate these competencies by completing the assignment sheet and job sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to shop operation with their definitions.
2. Distinguish among the basic categories of shop operation.
3. State purposes of parts management.
4. Select guidelines for maintaining good inventory control.
5. Match publications used for identifying part numbers with their descriptions.
6. Identify the parts of a job ticket.
7. Describe reasons for using standard time rate tables.
8. State reasons for using employee time cards.
9. Complete statements concerning payroll record keeping.
10. Complete a job ticket. (Assignment Sheet 1)
11. Use a computer system to obtain parts information. (Job Sheet 1)

Information Sheet

Objective 1

Terms and definitions

a. **Compensation**—Monetary value of an employee's total pay, including wages, employer's contribution to Social Security, paid vacations and holidays, health insurance, retirement plan, or other benefits

b. **Core charge**—Deposit required on a new part until the old part is returned to the parts distributor

Note: The old part is commonly rebuilt or remanufactured for use again.

c. **Employee time card**—Form used to record the amount of time a wage earner spends on a job; ordinarily used with a time clock

d. **Expiration date**—Date that generally is printed on a product container and tells the last date that the product is usable

e. **Job ticket**—Form completed to document equipment service and to record material and labor costs

Note: This may also be called the shop ticket, work order, or service order.

f. **Obsolete**—No longer in use

g. **Rotate**—To organize stocked parts and materials so that older quantities are used before newer quantities

h. **Scrappage**—Parts and materials that are unusable after service procedures, usually as a result of incorrect parts usage or improper service

i. **Standard time rate tables** (flat rate tables)—General guidelines for the amount of time required to perform various service procedures and their approximate flat rates

Note: These tables are usually based on national studies of actual field repairs and research studies.

j. **Warranty claim**—Request for reimbursement filed with an OEM or parts distributor for service work and/or parts used in a covered repair

Information Sheet

Objective 2

Basic categories of shop operation

a. **Parts management**—Selecting, ordering, stocking, issuing, and inventorying parts and materials required to support diesel equipment service

b. **Service management**—Keeping equipment service records and charging customers for material and labor costs associated with service

c. **Labor management**—Employing and compensating workers, including labor costs for customer service charges

Objective 3

Purposes of parts management

a. To obtain parts and materials

b. To maintain a stock of frequently used parts and materials

c. To organize the stock so that it is maintained in a safe, orderly, readily-accessible manner

d. To rotate stock

Note: Older stock needs to be used before it expires and before new stock is used.

e. To keep records of the types of parts in stock, their quantities, and their dollar value

f. To dispose of unneeded or obsolete parts and materials

Objective 4

Guidelines for maintaining good inventory control

a. Store parts so that they are physically separated from each other by part number.

b. Use a specific, written (documented) parts management process.

Note: A procedure that is not defined in writing cannot be accurately followed.

c. Address the specific needs of the business so that inventory levels are consistent with parts usage requirements, storage capacity, and financial status.

d. Document all parts transactions (receiving, stocking, issue, disposal, damage, etc.) so that each part is accounted for.

e. Limit the number of people who have direct access to parts. Control will be better because there is less chance for miscounting, for placing stock in the incorrect bins, for losing documentation, or for leaving transactions undocumented.

f. Computerize parts management to the degree that it benefits the company. Computers can automatically generate documentation, update inventory levels, identify parts shortages, track parts usage, and perform other parts management functions. They can be electronically connected to suppliers to order parts when inventory reaches set levels, check suppliers' stock, and track shipping and delivery of ordered parts. However, computerization can also be costly, time consuming, and frustrating if not matched to a company's needs, budget, and staff skills.

g. Conduct periodic physical inventories to verify parts counts, locate misplaced parts, and check the condition of stock. This may be done on a monthly, quarterly, semi-annual, or annual basis.

Objective 5

Publications used for identifying part numbers

a. **Parts manual (catalog)**—Shows illustrations and part names with their associated part numbers

b. **Service manual**—May give part numbers during the written service procedures

Note: If a parts manual is available, however, it should still be used to verify the part number and to make sure it is still current or has not been superseded by another number.

c. **Cross-reference manual**—Shows which OEM parts that a parts manufacturer's products replace; may list the part numbers of several manufacturers of a part

d. **Parts application charts**—List a product's intended use and generally accompany the product

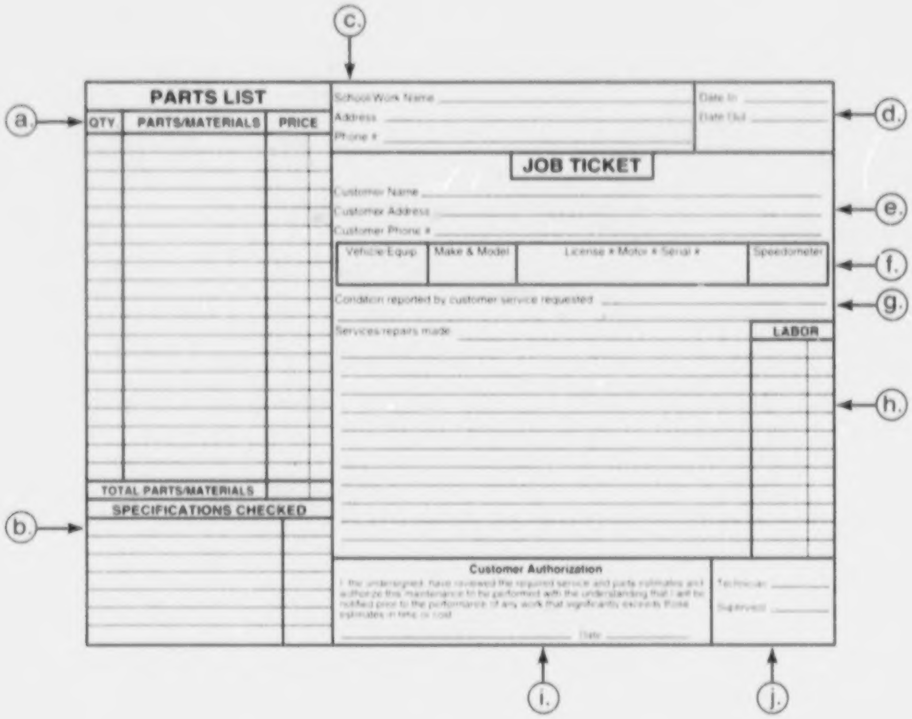
Note: They might be printed on the part's packaging or included in the instructions or on a separate sheet.

Information Sheet

Objective 6

Parts of a job ticket

Figure 1


c.
PARTS LIST
QTY
PARTS/MATERIALS
PRICE
a.
School/Work Name
Address
Phone #
Date In
Date Out
d.
JOB TICKET
Customer Name
Customer Address
Customer Phone #
e.
Vehicle/Equip
Make & Model
License # Motor # Serial #
Speedometer
f.
Condition reported by customer service requested
g.
Services/repairs made
LABOR
h.
TOTAL PARTS/MATERIALS
SPECIFICATIONS CHECKED
b.
Customer Authorization
Date
Technician
Supervisor
i.
j.

a. List of parts and materials used, including quantities and prices

b. Recording of specifications checked (such as torque values)

c. School or work (business) identification (name, address, phone #)

d. Date in and out

e. Customer identification (name, address, phone #)

f. Vehicle or equipment identification (make, model, license #, serial #)

g. Condition reported by customer (complaint) or service requested

h. Description of services/repairs made and labor charges

i. Customer authorization (signature and date by customer giving approval for service/repairs to be made as estimated)

j. Technician and supervisor signatures

Objective 7

Reasons for using standard time rate tables (flat rate)

a. To allow for more accurate charges based on labor requirement rather than on an individual's performance or specific problems (tool availability, parts delays, etc.) encountered during the procedure

b. To provide a means of budgeting work among technicians

c. To provide a basis for estimating completion times and for giving customers estimates of costs

d. To allow technicians to check their performance against national averages

e. To simplify accounting and billing procedures

f. To calculate labor charges on warranty claims

Objective 8

Reasons for using employee time cards

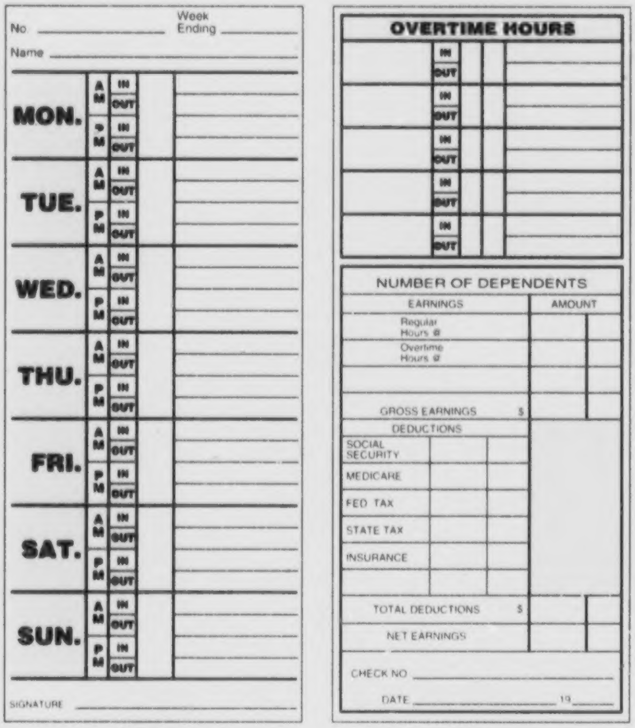
a. To ensure that the employee is compensated fairly for his/her time

b. To ensure that the employer receives the time on the job for which the employee is paid

c. To provide tax information as required by law

d. To assist the shop manager in evaluating and planning for personnel needs

Figure 2



No. ____________ Week Ending ____________
Name ____________

MON.	AM	IN	
		OUT	
	PM	IN	
		OUT	
TUE.	AM	IN	
		OUT	
	PM	IN	
		OUT	
WED.	AM	IN	
		OUT	
	PM	IN	
		OUT	
THU.	AM	IN	
		OUT	
	PM	IN	
		OUT	
FRI.	AM	IN	
		OUT	
	PM	IN	
		OUT	
SAT.	AM	IN	
		OUT	
	PM	IN	
		OUT	
SUN.	AM	IN	
		OUT	
	PM	IN	
		OUT	

SIGNATURE ____________

Front

OVERTIME HOURS

	IN	
	OUT	
	IN	
	OUT	
	IN	
	OUT	
	IN	
	OUT	
	IN	
	OUT	

NUMBER OF DEPENDENTS

EARNINGS			AMOUNT
Regular Hours @			
Overtime Hours @			
GROSS EARNINGS $			
DEDUCTIONS			
SOCIAL SECURITY			
MEDICARE			
FED TAX			
STATE TAX			
INSURANCE			
TOTAL DEDUCTIONS $			
NET EARNINGS			

CHECK NO ____________
DATE ____________ 19____

Back

Objective 9

Payroll record keeping

Note: For legal and accounting purposes, employers must keep detailed records.

a. An employee's payroll record begins with **gross pay**. This is the total wages or salaries before deductions.

b. Additional wages may be paid for **overtime** (over 40 hours per week).

Note: An employer must pay minimum wage. Anything over minimum wage, as well as overtime pay, are agreements between the employee and the employer.

c. Payroll records are typically calculated weekly, bi-weekly (every other week), or monthly.

d. **Mandatory withholdings** are then deducted from the gross pay. These include:

- FICA (Federal Insurance Contributions Act)—Contributions to Social Security and Medicare

- Income taxes—Federal and/or state taxes calculated based on the W-4 you signed with your employer

e. **Optional deductions** that you agree to pay for may include:

- Medical insurance—Health (hospitalization), dental, life, and/or disability insurance for you and your family
- Retirement accounts or pension funds
- Other savings or charitable contributions—Government savings bonds, credit union savings, United Way payroll deduction, etc.

f. Your take-home paycheck is also called your **net pay**. It is calculated in this way:

Gross pay – mandatory withholdings – optional deductions = net pay

g. Your employer must also make **mandatory contributions** on your behalf. These include:

- FICA—Matching contributions to Social Security and Medicare (employee pays 1/2 and employer pays 1/2 of the total contribution in your name)
- Unemployment insurance—Contributions to state-administered funds that can be used for limited periods by involuntarily unemployed workers (fired or laid off workers)
- Worker's Compensation—Contributions to state-administered funds that can be used by workers injured on the job

Note: The actual amounts paid to workers' compensation vary according to job classifications, the risk factors associated with that job, and the state where the dealer is located. For example, employers pay higher workers' compensation for truck drivers than for office workers.

h. The employer may also pay for **optional benefits**. These are not deducted from your paycheck. However, they are part of payroll record keeping procedures. These may include:

- Medical insurance
- Retirement benefits
- Paid leave—Sick days, vacation days, holidays
- Bonuses

Objective 10

Assignment Sheet 1—Complete a Job Ticket

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Directions are followed	______
• Information entered is correct	______
• Information entered is complete	______
• Calculations are correct	______
• Form is complete, neat, and legible	______

Basic Skills

Reading Writing Mathematics Critical Thinking

Introduction

Job tickets summarize the work done and the parts used to complete a service job. They help to assure the customer that charges are reasonable, and they assist the technician in keeping track of materials and parts. Most service centers use standard forms such as the one in Figure 1.

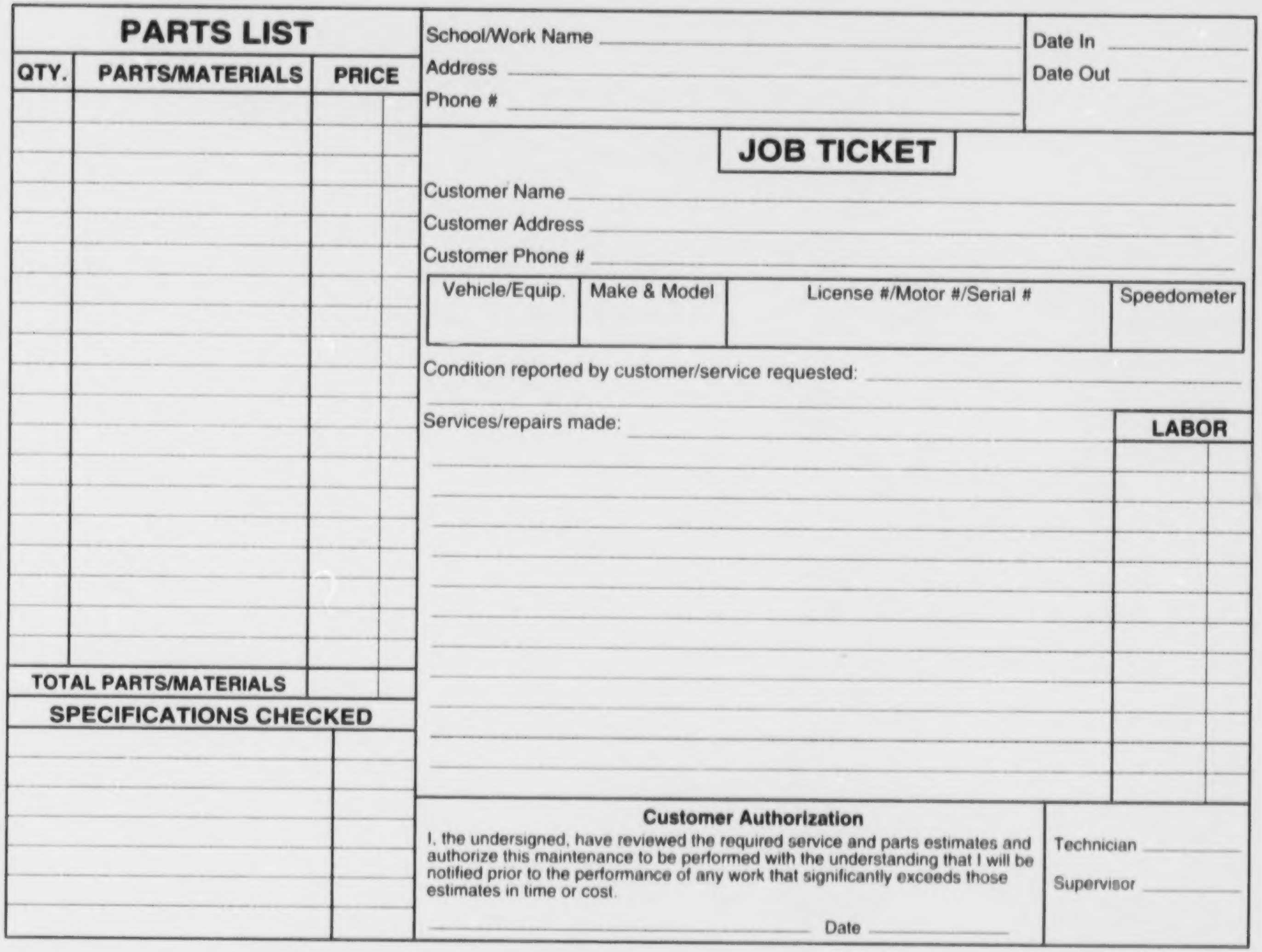
Materials List

- Pen or pencil
- Job ticket used in your shop (optional)
- Calculator

Directions

Assume that you have replaced the water pump on a Cummins NT855 Big Cam III engine owned by Mr. Robert Jones of your town. The process involved draining the cooling system, removing the water pump, installing a new gasket and water pump, replacing a worn water pump belt, and refilling the coolant system with a 50 % solution of water and ethylene glycol antifreeze. Using the price lists and flat rate table provided by your instructor, complete the sample job ticket in Figure 1 or the standard job ticket used in your shop also provided by your instructor.

Figure 1—Sample job ticket



PARTS LIST

QTY.	PARTS/MATERIALS	PRICE
TOTAL PARTS/MATERIALS		

SPECIFICATIONS CHECKED

School/Work Name

Address

Phone #

Date In

Date Out

JOB TICKET

Customer Name

Customer Address

Customer Phone #

Vehicle/Equip.	Make & Model	License #/Motor #/Serial #	Speedometer

Condition reported by customer/service requested:

Services/repairs made:

LABOR

Customer Authorization

I, the undersigned, have reviewed the required service and parts estimates and authorize this maintenance to be performed with the understanding that I will be notified prior to the performance of any work that significantly exceeds those estimates in time or cost.

Date

Technician

Supervisor

Objective 11

Job Sheet 1—Use a Computer System to Obtain Parts Information

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Correct computer files are identified	______
• Correct information is provided	______
• Equipment and discs are handled with care	______
• Clean-up and follow-up actions are adequate	______

Basic Skills

Reading Writing Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Computer system
- Appropriate diskettes or CDs

Procedure

Note: Before attempting to perform this task, you should have watched your instructor's demonstration of the use of computer equipment in you facility.

☐ 1. Start up computer and load appropriate diskettes.

☐ 2. Obtain the following numbers and related information for your assigned vehicle or equipment.

Make/brand ______________________________

Model/type and code ______________________________

____

Parts manual ______________________________

Section/page # ______________________________

Part	Part number	Price	Min. quantity
Piston	______	______	______
Crankshaft	______	______	______
Injector	______	______	______
Air filter	______	______	______
Gasket set—Complete engine overhaul	______	______	______
Injection pump	______	______	______
______	______	______	______
______	______	______	______

☐ 3. Show information to instructor for approval.

☐ 4. Turn off computer as instructed.

Evaluator's Comments: ______________________

____

____

595

Unit Contents

Student Components

Student Page

Objective Sheet 1B–3

Information Sheet 1B–5

Student Supplements

- 1—Wrench Sizes for Standard and Metric Threaded Fasteners 1B–27
- 2—Tensile Strength of Standard Grade U.S. and Metric Threaded Fasteners 1B–29

Assignment Sheets

- 1—Measure U.S. Customary Bolts and Threads 1B–31
- 2—Measure Metric Bolts and Threads 1B–35
- 3—Match Bolts With the Correct Size Wrenches 1B–39

Job Sheets

- 1—Extract a Broken Bolt, Stud, or Screw 1B–41
- 2—Restore External Threads 1B–45
- 3—Cut and Restore Internal Threads 1B–47
- 4—Install a Thread Insert 1B–51

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and measure various types of mechanical fasteners, remove seized threaded fasteners, and repair threaded fasteners and tapped holes. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to mechanical fasteners with their definitions.
2. Select from a list the characteristics of satisfactory fasteners.
3. Identify typical threaded fasteners.
4. Complete statements concerning characteristics of threaded fasteners.
5. Identify typical bolt head designs.
6. Identify typical machine screw head designs.
7. Identify typical nuts.
8. Identify typical nuts and bolts with locking or self-locking features.
9. Identify devices used for securing threaded fasteners.
10. Identify typical nonthreaded fasteners.
11. Select tools used to remove seized threaded fasteners.
12. Complete statements concerning anti-seize compounds.
13. Identify parts of a tap and die set.
14. Distinguish among tools used to restore or replace threads on threaded fasteners.
15. Match types of taps with their functions.
16. Measure U.S. customary bolts and threads. (Assignment Sheet 1)
17. Measure metric bolts and threads. (Assignment Sheet 2)
18. Match bolts with the correct size wrenches. (Assignment Sheet 3)
19. Extract a broken bolt, stud, or screw. (Job Sheet 1)
20. Restore external threads. (Job Sheet 2)

21. Cut and restore internal threads. (Job Sheet 3)
22. Install a thread insert. (Job Sheet 4)

598

Information Sheet

Objective 1

Terms and definitions

a. **Adhesive**—Substance such as glue or cement used to hold objects together

b. **Bolt**—Metal rod or pin that has a head at one end, a screw thread at the other end, and is secured by a nut; used for fastening objects together

c. **Cap screw**—Externally threaded fastener which must be torqued by its head into a tapped hole

d. **Die**—Internally threaded screw cutting tool; used for forming external screw threads

e. **Fastener**—Device or substance used to hold parts together

f. **Metric**—Decimal system of measurement based on the meter, liter, and gram

g. **Nut**—Internally threaded fastener screwed onto the end of a bolt to hold objects together

h. **Penetrating oil**—Thin oil used to remove seized fasteners

i. **Rethread**—To restore or replace damaged threads

j. **SAE**—Society of Automotive Engineers

k. **Screw**—Pointed and headed cylindrical fastener that is threaded and designed for insertion into material by rotating

l. **Seized fastener**—Threaded fastener that is stuck and can no longer be turned, usually due to rust or corrosion

m. **Self-tapping fastener**—Bolt or screw designed to cut its own threads as it is screwed into a drilled hole

n. **Stud**—Steel rod with threads on both ends, to be screwed permanently into a fixed part at one end and receive a nut on the exposed end; usually used where aligning a bolt with a hole might be difficult

o. **Tap**—Externally threaded screw cutting tool; used for forming internal screw threads

p. **Tapped hole**—Hole in which internal threads have been cut

q. **Tensile strength**—Amount of lengthwise force an object can withstand without pulling apart

r. **Thread**—Raised spiral ridge of a bolt, screw, nut, or tapped hole

s. **Threaded**—Having threads

t. **Torque**—Turning or twisting force that measures nut tightness

u. **U.S. customary**—System of measurement based on the foot, gallon, and pound

v. **USS**—United States standard

w. **Washer**—Flat, thin ring used with nuts, bolts, or screws to secure a threaded fastener

Objective 2

Characteristics of satisfactory fasteners

a. Strength

b. Reusability

c. Ease of removal

d. Ability to withstand vibration

e. Durability

f. Resistance to corrosion

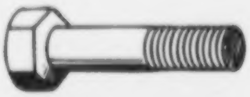
g. Resistance to temperature extremes

Objective 3

Typical threaded fasteners

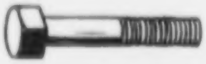
a. **Bolt**—Used with a nut to fasten two or more parts

Figure 1



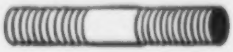
b. **Cap screw**—Torqued into a tapped hole in one of the parts being fastened

Figure 2



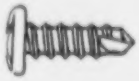
c. **Stud**—Torqued into a tapped hole on one end and accepts a nut on the other; useful in installations where aligning parts is difficult

Figure 3



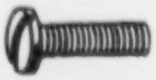
d. **Self-tapping screw**—Has threads that are shaped to cut into its own hole when driven into plastic or soft metal workpieces

Figure 4



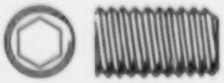
e. **Machine screw**—Services the same purpose as a bolt and cap screw, but it is usually used in smaller parts

Figure 5



f. **Set screw**—Used where a bolt or screw head would impede the motion of a rotating part

Figure 6



g. **Nut**—Used with bolt, stud, or machine screw

Figure 7

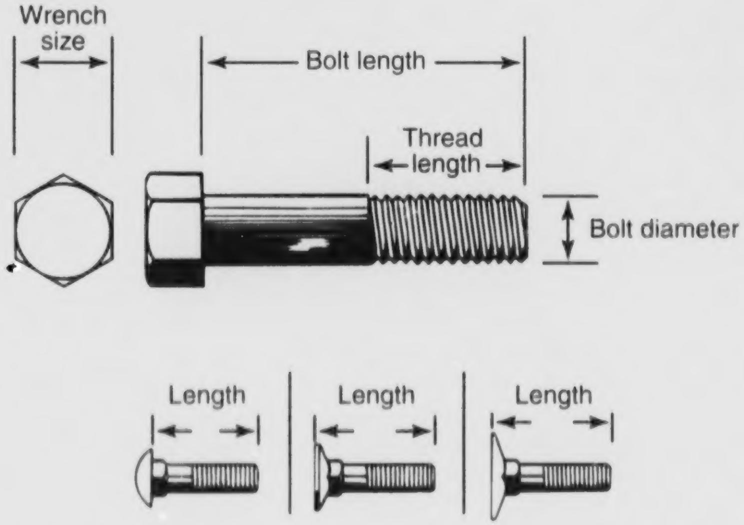
Objective 4

Characteristics of threaded fasteners

a. **General dimensions**

- Diameter—Stated as the outside diameter of the threads (or the width of the shaft at the base of the head)
- Length—Distance from the base of the head to the tip
- Thread length—Distance of the threaded portion
- Wrench size—The distance between parallel sides of a bolt's head (See Student Supplement 1 for more information.)

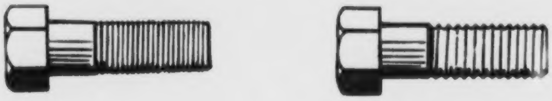
Figure 8—Threaded fastener dimensions



b. **Thread size**

- Correct thread size (or "pitch") is critical to a threaded fastener's ability to work properly.
- Standard thread sizes depend on the fastener's diameter and whether its threads are fine or course.

Figure 9—Types of threads



National Fine (NF) - - SAE National Coarse (NC) - - USS

- The size of U.S. customary threads is stated as the number of threads per inch.

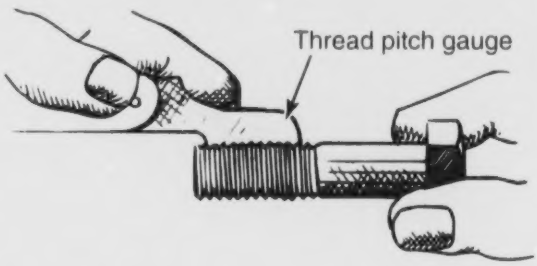
  Example: A threaded fastener with a thread size of 16 would have sixteen threads per inch.

- The size of metric threads is stated as the number of millimeters between threads

  Example: A metric fastener with a thread size of 2 would have two millimeters between threads.

- Threads should be measured with a thread pitch gauge. Choose U.S. or metric depending on the thread.

Figure 10—Measuring threads per inch



c. **Grade**

- A threaded fastener's grade depends on its tensile strength—the amount of lengthwise (or stretching) force it can withstand before it pulls apart.

- While a threaded fastener's tensile strength is stated as its breaking point, such as 55,000 pounds, its grade is stated as a number such as "8" (U.S. customary) or 8.8 (metric).

- The higher the grade number, the greater the tensile strength. (See Student Supplement 2 for more information.)

- Threaded fasteners often are marked to show their grade. Bolts and cap screws are marked on their heads.

- U.S. customary fasteners use a system of lines or dashes in which the grade number is two greater than the number of lines.

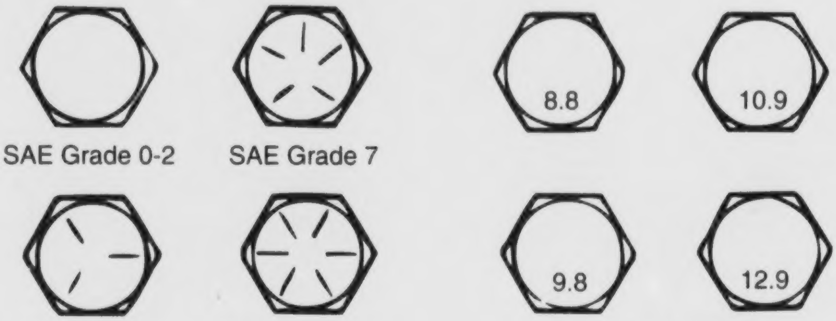
  Example: A U.S. customary bolt grade five would be marked with three lines.

- U.S. customary nuts can be marked top and bottom with a similar system of dots in which three dots indicate grade five, or with a system of notches on their sides.

- Metric fasteners are simply stamped with their grade number.

- Threaded fasteners which are not reusable should always be replaced with threaded fasteners of equal or higher grade.

Figure 11—Common grade markings



SAE Grade 0-2 SAE Grade 7

SAE Grade 5 SAE Grade 8

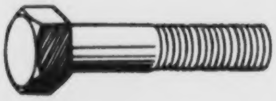
Metric Property Classes

Objective 5

Typical bolt head designs

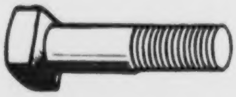
a. **Hex head**—Most commonly used head design; provides a good fit for wrenches and a secure installation

Figure 12



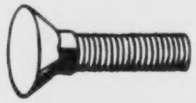
b. **Square head cap screw**—Used in installations that don't require as tight a fit as a hex head

Figure 13



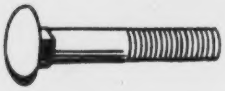
c. **Plow head**—Allows the bolt to fit flush and secure in the workpiece

Figure 14



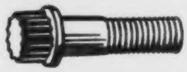
d. **Carriage bolt**—Fits securely in the workpiece, like a plow head bolt, but used when a fit flush with the surface of the workpiece is not needed

Figure 15



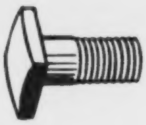
e. **Twelve-point head**

Figure 16



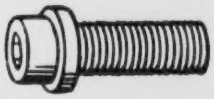
f. **Askew head**

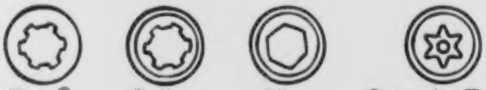
Figure 17



g. **Socket head**—Has special head with indented screwdriver hole that requires less room for a wrench than hex or square heads; easy to use and provides a good fit with the special drivers

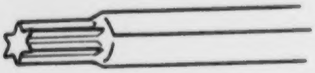
Figure 18





h. **External Torx® head**—Special head requires use of Torx® socket

Figure 19

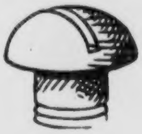


Objective 6

Typical machine screw head designs

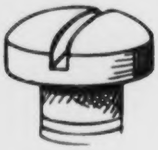
a. Round

Figure 20



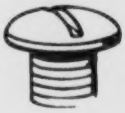
b. Fillister

Figure 21



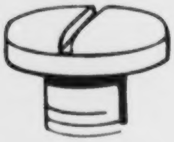
c. Truss

Figure 22



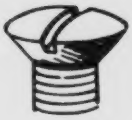
d. Pan

Figure 23



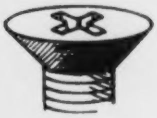
e. Oval

Figure 24



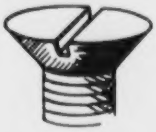
f. Cross recessed or Phillips®

Figure 25



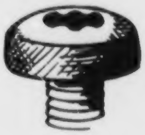
g. Flat

Figure 26



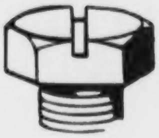
h. Clutch

Figure 27



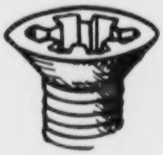
i. Hex slotted

Figure 28



j. Torx®

Figure 29

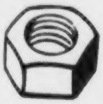


Objective 7

Typical nuts

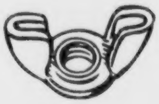
a. **Hex nut**—Offers a good fit for wrenches and provides secure installation

Figure 30



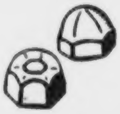
b. **Wing nut**—Can be tightened by hand in installations requiring ease of removal

Figure 31



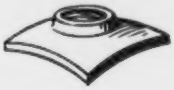
c. **Acorn nut**—Covers bolt ends and is used for protection or decoration

Figure 32



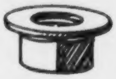
d. **Spring nut**—Creates tension against the bolt head and workpiece, ensuring a strong installation

Figure 33



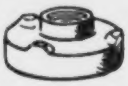
e. **Flanged nut**—Distributes pressure around a larger area, making it less likely to damage the workpiece

Figure 34



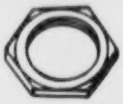
f. **Weld nut**

Figure 35



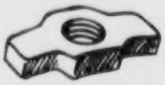
g. **Panel nut**—Uses less room than a conventional nut

Figure 36



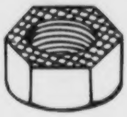
h. **Specialty nut**

Figure 37



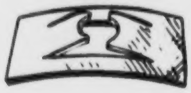
i. **Serrated nut**—Has a textured gripping surface that helps ensure secure installation

Figure 38



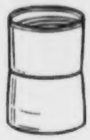
j. **Speed nut**—Slips over the end of a bolt and stud

Figure 39



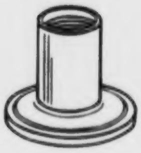
k. **Nutsert®**

Figure 40



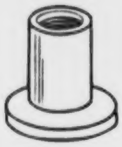
l. **T-nut**

Figure 41



m. **Well nut**

Figure 42

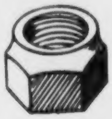


Objective 8

Typical nuts and bolts with locking or self-locking features

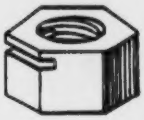
a. Lock

Figure 43



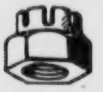
b. Distorted thread

Figure 44



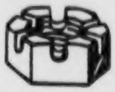
c. Castle

Figure 45



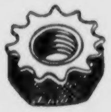
d. Slotted (used with cotter pin)

Figure 46



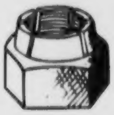
e. Flange lock or self-locking

Figure 47



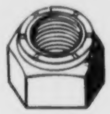
f. Prevailing torque lock

Figure 48



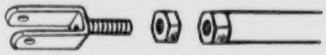
g. Plastic insert lock

Figure 49



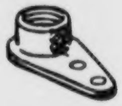
h. Jam

Figure 50



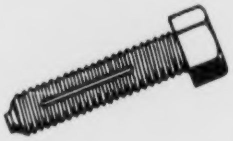
i. Anchor

Figure 51



j. Thread lock bolt (nylon insert)

Figure 52



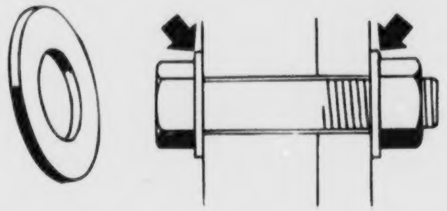
Objective 9

Devices used for securing threaded fasteners

a. **Washers**—Reinforce torque and distribute pressure, helping to prevent damage to the workpiece's surface

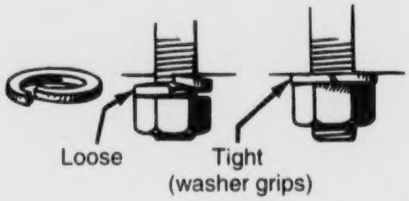
- Anchor

Figure 53



- Lock

Figure 54

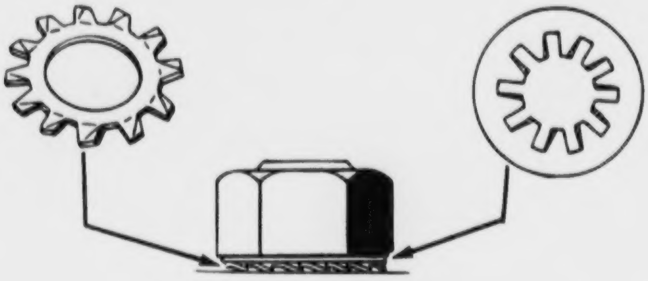


- External toothed lock

  Figure 55

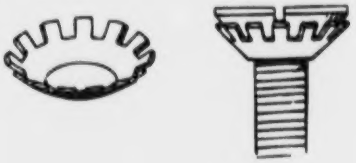
- Internal toothed lock

  Figure 56



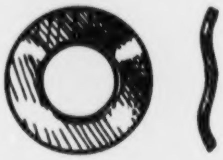
- Countersunk

  Figure 57



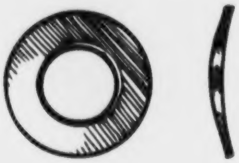
- Wave (spring)

  Figure 58



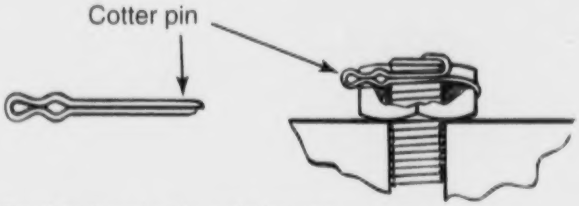
- Spring (Belleville)

  Figure 59

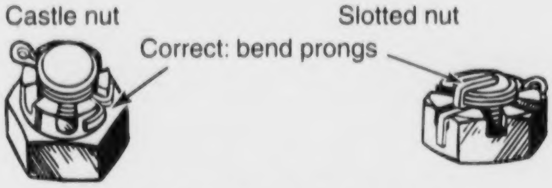


b. **Cotter pins**—Used to prevent slippage of castle nuts and slotted nuts

Figure 60



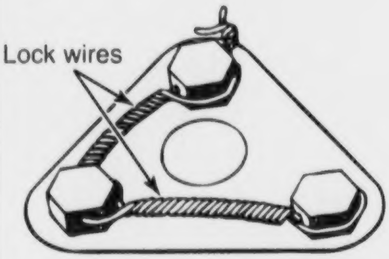
Double-head cotter pin in use


Castle nut
Slotted nut
Correct: bend prongs

Cotter pin prongs properly bent around castle nut and a slotted nut

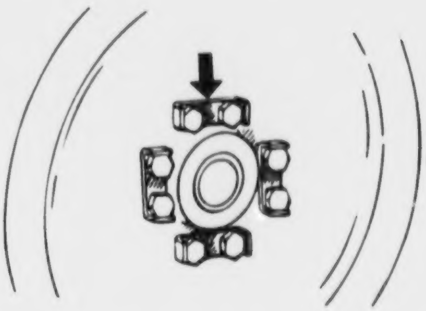
c. **Lock (safety) wires**—Can secure installations of two or more threaded fasteners

Figure 61



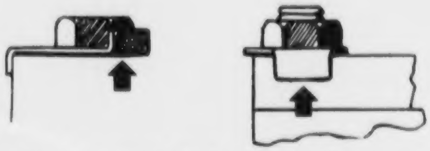
d. **Flat metal locks**—Hold flywheel bolts in place

Figure 62



e. **Lock ears**—Secure fasteners that are near the edge of the workpiece

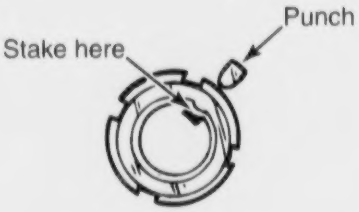
Figure 63



Lock ears properly bent into place

f. **Staking nut**—Used to secure compression mounting bolt

Figure 64



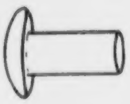
Objective 10

Typical nonthreaded fasteners

a. **Rivets**—Used for permanent installations and are not reusable

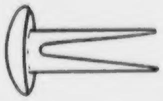
- General purpose

Figure 65



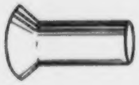
- Split

Figure 66



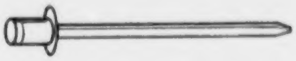
- Countersunk

Figure 67



- Hollow (pop)

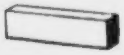
Figure 68



b. **Keys**—Fit in slotted openings and hold pulleys, gears, and collars on shafts

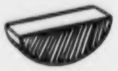
- Square key

Figure 69



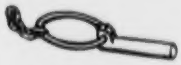
- Woodruff key

Figure 70



c. **Lock pin**—Used in installations requiring ease of removal when secure fit is not critical

Figure 71

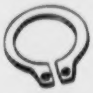


d. **Snap rings**—Fit in grooves on the inside or outside of shafts, preventing other parts from sliding along the shaft

Note: Most snap rings have a flat side and a round side. The rule for installing a snap ring is to put the round side to the load.

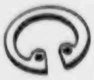
1) External hole

Figure 72



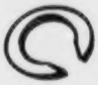
2). Internal hole

Figure 73



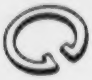
3) Lock ring

Figure 74



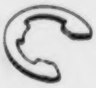
4). Internal prong

Figure 75



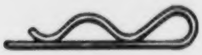
5) External "E"

Figure 76



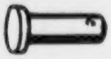
e. **Spring lock pin**—Fits through hole in shaft to prevent other parts from moving along the shaft

Figure 77



f. **Clevis pin**—Allows easy removal in installations that do not require a tight fit

Figure 78

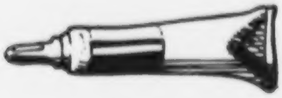


612

g. **Adhesive**—Fixes threaded fasteners permanently in place

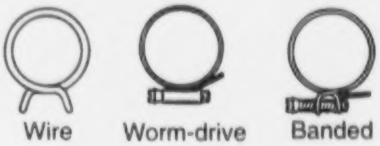
Example: Loctite®

Figure 79



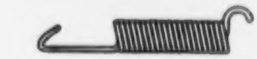
h. **Clamps**—Used to hold soft tubes such as hoses on hard tubular fittings

Figure 80


Wire
Worm-drive
Banded

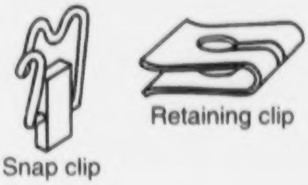
i. **Springs**—Hold parts together by creating tension

Figure 81



j. **Clips**—Include a wide variety of devices that hold parts in place; many are designed for easy opening; others are harder to remove

Figure 82

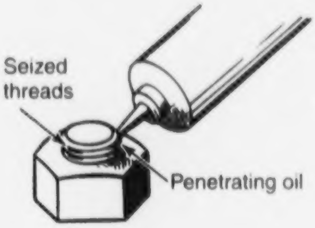

Retaining clip
Snap clip

Objective 11

Tools used to remove seized threaded fasteners

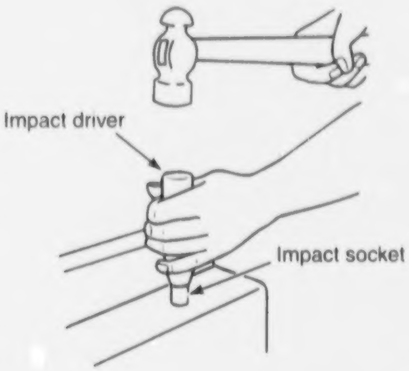
a. **Penetrating oil**—Thin lubricant that can flow between seized parts

Figure 83


Seized threads
Penetrating oil

b. **Impact driver**—Converts the striking force of the hammer to torque

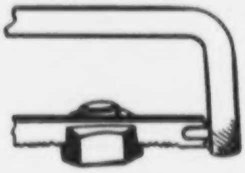
Figure 84


Impact driver
Impact socket

c. **Hacksaws, nut splitters, and chisels**—Used to cut off threaded fasteners that cannot be removed with an impact driver

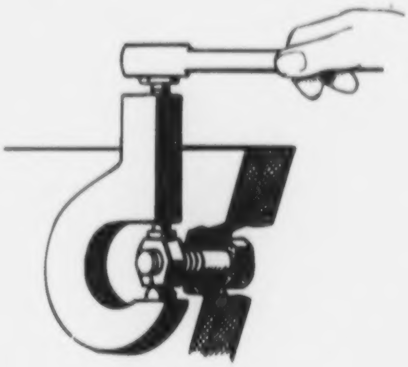
- Hacksaw

Figure 85



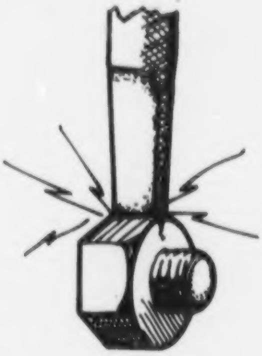
- Nut-splitter

Figure 86



- Chisel

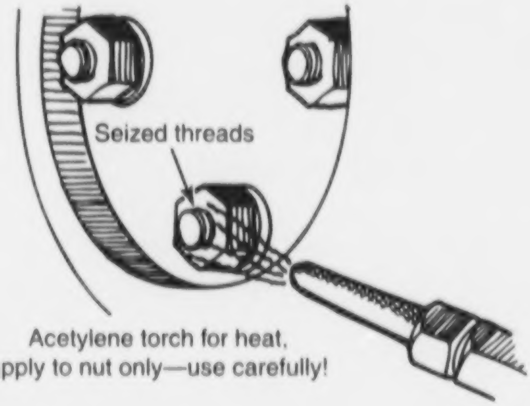
Figure 87



614

d. **Acetylene torches**—Must be used carefully and only on installations that do not present a fire hazard; apply heat to the nut only

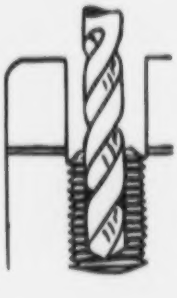
Figure 88


Seized threads
Acetylene torch for heat, apply to nut only—use carefully!

e. **Drills and extractors**—Used to remove seized fasteners that have broken off below the surface of the workpiece

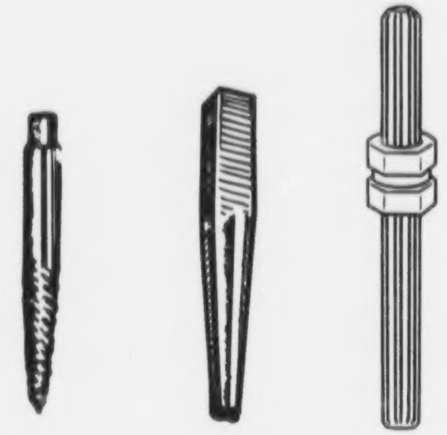
- Drill

  Figure 89



- Extractor (or "easy-out")

  Figure 90



Tapered screw (spiral)

Tapered straight screw (square)

Straight screw (hex nut)

Information Sheet

Objective 12

Anti-seize compounds

a. Are paste-type compounds and coatings for threaded fasteners that allow for easy removal of these fasteners from their workpieces

b. Prevent fasteners from "seizing" or rusting in place

c. Two basic types:

- Graphite-based—Applied to bolts and fasteners prior to installation; used in applications where temperature is not a factor
- Graphite-based with glass beads—Used in high temperature applications (i.e. exhaust systems) where high temperatures would burn away the graphite. Glass beads maintain interference fit. As bolt or fastener is attempted to be removed, beads get crushed, providing enough clearance to remove the fastener.

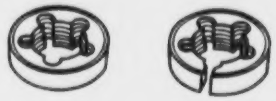
Objective 13

Parts of a tap and die set

Note: These parts are used for cutting new threads. Other taps and dies called rethreading taps are dies used for restoring threads.

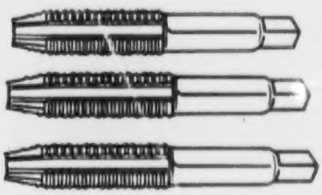
a. **Dies**—Available in NC, NF, or metric sizes; solid (one-piece) or adjustable (split); hex or round shapes

Figure 91



b. **Taps**—Available in NC, NF, or metric sizes

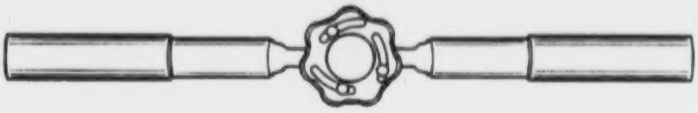
Figure 92



c. **Threading tools**

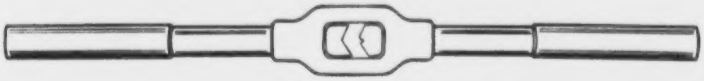
- Die stock—Die is locked in stock; used to maintain proper alignment for threading

  Figure 93



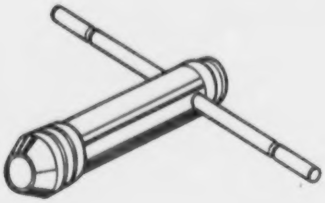
- Tap wrenches—Used for turning taps
  - Adjustable handle

    Figure 94



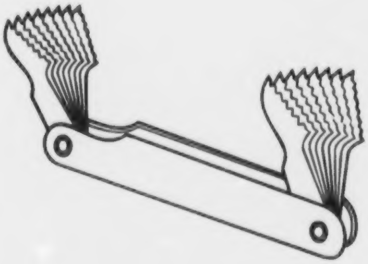
  - T-handle

    Figure 95



- Thread pitch gauges (U.S. or metric)—Used to determine thread pitch

  Figure 96



Note: A screwdriver is also needed for adjusting dies.

Information Sheet

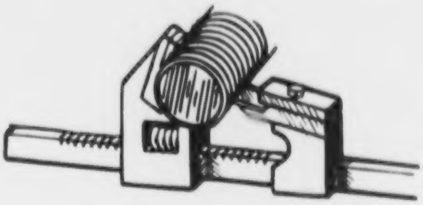
Objective 14

Tools used to restore or replace threads on threaded fasteners

a. For restoring external threads

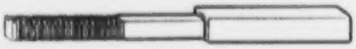
- Rethreading tool (external chaser)

Figure 97



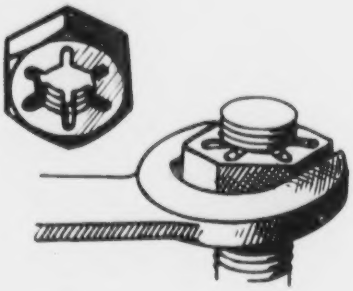
- Thread file

Figure 98



- Rethreading die

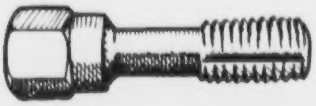
Figure 99



b. For restoring internal threads

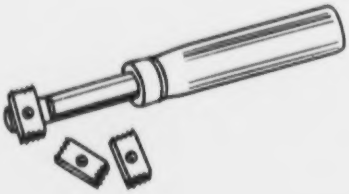
- Rethreading hand tap

Figure 100



- Internal thread chaser

Figure 101



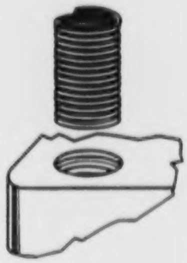
Note: Most rethreading taps and dies are color-coded—Silver for NC threads, black for NF threads, and gold for metric threads.

618

c. For replacing/repairing internal threads

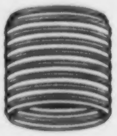
- Locking threaded inserts

  Figure 102



- Coiled threaded insert

  Figure 103

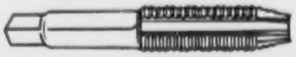


Objective 15

Types of taps and their functions

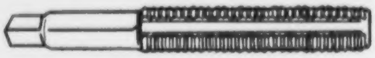
a. **Taper**—Used to start the thread

Figure 104



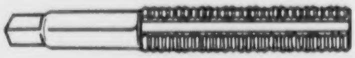
b. **Plug**—Used after the taper tap has cut the threads as far as possible

Figure 105



c. **Bottoming**—Used last to cut the thread to the bottom of the hole (if necessary)

Figure 106



Student Supplement 1—Wrench Sizes for Standard and Metric Threaded Fasteners

Introduction: The dimensions of U.S. customary fasteners are usually stated in inches and fractions of inches. Those with a diameter smaller than one-fourth inch are designated by size number (1, 2, 3, etc.), zero being the smallest. The dimensions of metric threaded fasteners are stated in millimeters.

U.S. CUSTOMARY		**METRIC**	
Fastener Size	**Wrench Size**	**Fastener Size**	**Wrench Size**
1/4"	7/16"	6	10
5/16"	1/2"	7	11
3/8"	9/16"	8	13
7/16"	5/8" or 11/16"	10	17
1/2"	3/4"	12	19
9/16"	13/16" or 7/8"	14	22
5/8"	15/16"	16	24
11/16"	1 or 1 1/16"		
3/4"	1 1/8"		
7/8"	1 1/4"		
1"	1 1/2"		

Student Supplement 2—Tensile Strength of Standard Grade U.S. and Metric Threaded Fasteners

U.S. CUSTOMARY		METRIC	
Grade	Tensile Strength	Grade (Property Class)	Tensile Strength
1 or 2	64,000 psi	5.8	75,400 psi
5	100,000 psi	8.8	120,350 psi
6	133,000 psi	9.8	130,500 psi
8	150,000 psi	10.9	150,800 psi
		12.9	176,900 psi

Objective 16

Assignment Sheet 1—Measure U.S. Customary Bolts and Threads

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Followed directions	______
• Measured bolts correctly	______
• Stated correct grade and torque specifications for bolts	______

Basic Skills

Reading Mathematics Critical Thinking

Introduction

As a diesel technician, you will often have to replace damaged or missing U.S. customary threaded fasteners. Using the right size and grade of threaded fastener is crucial to the installation's reliability and safety. This exercise will familiarize you with how to measure and grade standard U.S. customary threaded fasteners.

Materials List

- Bolts to be measured
- Steel rule or measuring tape

Directions

Your instructor will give you five standard U.S. customary bolts. Measure each bolt's length, diameter, and threads per inch. Then give the dimensions, grade, and torque specification for the bolt in the blanks provided.

Bolt 1

Diameter __________

Length __________

Thread Length __________

Correct Wrench Size __________

Thread Pitch __________

Grade __________

Torque Specification __________

Bolt 2

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade ____________

Torque Specification ____________

Bolt 3

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade ____________

Torque Specification ____________

Bolt 4

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade ____________

Torque Specification ____________

Bolt 5

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade ____________

Torque Specification ____________

Hand in the completed assignment to your instructor.

Objective 17

Assignment Sheet 2—Measure Metric Bolts and Threads

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	**Rating**
• Followed directions	______
• Measured bolts correctly	______
• Stated correct grade and torque specifications for bolts	______

Basic Skills

Reading Mathematics Critical Thinking

Introduction

As a diesel technician, you will often have to replace damaged or missing metric threaded fasteners. Using the right size and grade of threaded fastener is crucial to the installation's reliability and safety. This exercise will familiarize you with how to measure and grade standard metric threaded fasteners.

Materials List

- Metric bolts to be measured
- Steel rule or measuring tape

Directions

Your instructor will give you five metric bolts. Measure each bolt's length, diameter, and threads per inch. Then give the dimensions, grade, and torque specification for the bolt in the blanks provided.

Bolt 1

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade/Class ____________

Torque Specification ____________

Bolt 2

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade/Class ____________

Torque Specification ____________

Bolt 3

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade/Class ____________

Torque Specification ____________

Bolt 4

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade/Class ____________

Torque Specification ____________

Bolt 5

Diameter ____________

Length ____________

Thread Length ____________

Correct Wrench Size ____________

Thread Pitch ____________

Grade/Class ____________

Torque Specification ____________

Objective 18

Assignment Sheet 3—Match Bolts With the Correct Size Wrenches

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Followed the directions	_____
• Matched bolts with correct size wrenches	_____

Basic Skills

Reading

Introduction

As a diesel technician, you will often have to install and remove threaded fasteners with hex heads. Using the correct size wrench will make the job easier and help prevent damaging the fastener.

Directions

Using the table from Student Supplement 1, match the wrench sizes on the right with the correct bolt sizes. Write your answers in the blanks provided.

U.S. CUSTOMARY

	Bolt size (diameter)	Wrench size
____	a. 1/4"	1. 1/2"
____	b. 5/16"	2. 3/4"
____	c. 3/8"	3. 13/16" or 7/8"
____	d. 7/16"	4. 1 1/8"
____	e. 1/2"	5. 5/8" or 11/16"
____	f. 9/16"	6. 9/16"
____	g. 5/8"	7. 1 1/2"
____	h. 11/16"	8. 1 1/4"
____	i. 3/4"	9. 7/16"
____	j. 7/8"	10. 1" or 1 1/16"
____	k. 1"	11. 15/16"

METRIC

		Bolt size (diameter)		Wrench size
____	l.	6	12.	22
____	m.	7	13.	17
____	n.	8	14.	24
____	o.	10	15.	10
____	p.	12	16.	13
____	q.	14	17.	19
____	r.	16	18.	11

Objective 19

Job Sheet 1—Extract a Broken Bolt, Stud, or Screw

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Followed safety rules throughout procedure	______
• Drew drill to center of bolt correctly	______
• Drilled bolt without damaging tapped hole	______
• Extracted fastener without damaging tapped hole	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Electric drill, 1/2″ chuck
- Twist drill
- Center punch
- Screw extractors
- Ball peen hammer
- Lubricating oil

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Make a center punch mark close to center of broken bolt.

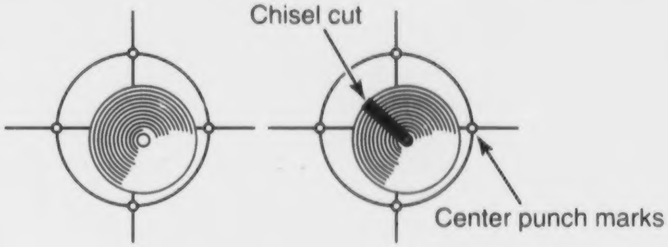
☐ 2. Enlarge the center punch mark slightly with drill bit at drill's lowest speed. Use lubricating oil on bit while drilling.

☐ 3. Remove drill before whole point of bit has entered the material.

☐ 4. Check to see if hole is at center of bolt. If not, proceed as follows.

☐ 5. Make a chisel cut on the side of the hole to which the drill should be drawn.

Figure 1—How to draw the drill back to the correct center

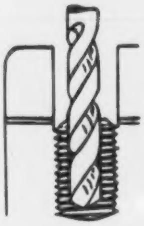


☐ 6. Make another punch for new center.

☐ 7. Repeat step 2 above.

☐ 8. After getting to center of bolt, enlarge the hole sufficiently to insert the extractor tool.

Figure 2

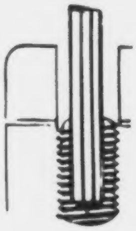


Note: Try to drill the hole over to the total length of the bolt to reduce stress on the threads.

☐ 9. Select extractor that will fit drilled hole from those available in your shop.

☐ 10. Tap the extractor lightly into the drill hole.

Figure 3



631

☐ 11. Carefully turn extractor counterclockwise to remove the bolt, stud, or screw. Don't break the extractor inside the bolt.

☐ 12. After bolt is extracted, blow out bolt hole with compressed air.

☐ 13. Clean area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 20

Job Sheet 2—Restore External Threads

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Restored bolt or threaded rod by appropriate procedure	______
• Threaded bolt or rod functions properly	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

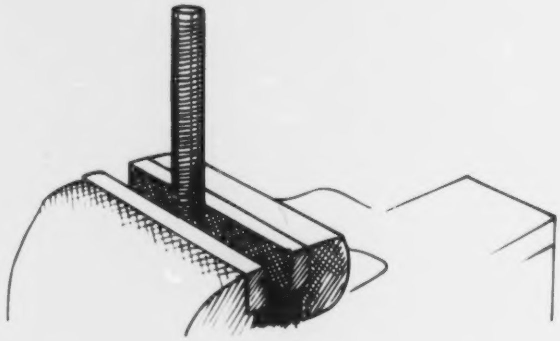
- Die
- Die stock
- Vise
- Flat file
- Cutting oil
- Damaged bolt or threaded rod

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Place bolt or threaded rod on vise.

Figure 1



☐ 2. Chamfer end of rod with file. (To chamfer means to form an end that is cut away at an angle.)

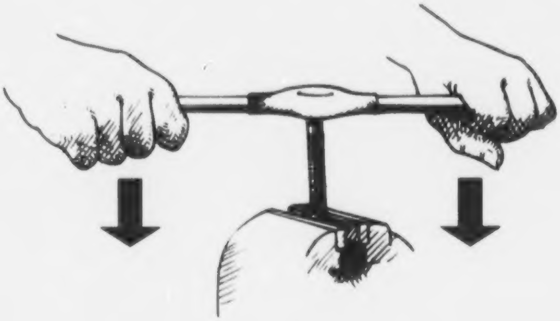
☐ 3. Lubricate end of rod with cutting oil.

☐ 4. Place die in die stock and secure it.

☐ 5. Place die on top of rod with tapered side facing down.

☐ 6. Start die straight on the rod, and press down evenly while turning the die.

Figure 2



☐ 7. Apply a few drops of cutting oil while turning the die, and check die often for squareness.

☐ 8. Continue this procedure until the desired amount of threads have been restored.

☐ 9. Remove die by turning counterclockwise.

☐ 10. Hold onto the die stock firmly while removing it so as not to drop it when it comes to the end of the threads.

☐ 11. Clean threads with a brush.

☐ 12. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ________________________________

____

____

634

Objective 21

Job Sheet 3—Cut and Restore Internal Threads

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout	______
• Cut internal threads by appropriate procedure	______
• Internal threads function properly	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Taps, cutting and rethreading
- Tap wrench
- Drill motor
- Tap drill
- Vise
- Cutting oil
- Stock to be drilled and threaded
- Damaged tapped hole

Caution: Follow all shop safety procedures.

Procedure

Cutting internal threads

☐ 1. Place workpiece in vise.

☐ 2. Select the proper tap drill using the following tables.

Note: On some taps the size of the drill bit required will be stamped on the back.

Table 1—Coarse Thread Dimensions

Unified and American National Coarse Series, UNC, NC

Size of Thread and Threads Per Inch	Major Diameter in Inches	Pitch Diameter in Inches	Minor Diameter of External Threads in Inches	Commercial Tap Drill for About 75% Thread	Decimal Equivalent of Tap Drill in Inches
5 x 40	0.1250	0.1088	0.0943	No. 38	0.1015
6 x 32	0.1380	0.1177	0.0997	No. 36	0.1065
8 x 32	0.1640	0.1437	0.1257	No. 29	0.1360
10 x 24	0.1900	0.1629	0.1389	No. 25	0.1495
12 x 24	0.2160	0.1889	0.1649	No. 16	0.1770
1/4 x 20	0.2500	0.2175	0.1887	No. 7	0.2010
5/16 x 18	0.3125	0.2764	0.2443	F	0.2570
3/8 x 16	0.3750	0.3344	0.2983	5/16	0.3125
7/16 x 14	0.4375	0.3911	0.3499	U	0.3680
1/2 x 13	0.5000	0.4500	0.4056	27/64	0.4219
9/16 x 12	0.5625	0.5084	0.4603	31/64	0.4844
5/8 x 11	0.6250	0.5660	0.5135	17/32	0.5312
3/4 x 10	0.7500	0.6850	0.6273	21/32	0.6562
7/8 x 9	0.8750	0.8028	0.7387	49/64	0.7656
1 x 8	1.0000	0.9188	0.8466	7/8	0.8750

Table 2—Fine Thread Dimensions

Unified and American National Fine Series, UNF, NF

Size of Thread and Threads Per Inch	Major Diameter in Inches	Pitch Diameter in Inches	Minor Diameter of External Threads in Inches	Commercial Tap Drill for About 75% Thread	Decimal Equivalent of Tap Drill in Inches
5 x 44	0.1250	0.1102	0.0971	No. 37	0.1040
6 x 40	0.1380	0.1218	0.1073	No. 33	0.1130
8 x 36	0.1640	0.1460	0.1299	No. 29	0.1360
10 x 32	0.1900	0.1697	0.1517	No. 21	0.1590
12 x 28	0.2160	0.1928	0.1722	No. 14	0.1820
1/4 x 28	0.2500	0.2268	0.2062	No. 3	0.2130
5/16 x 24	0.3125	0.2854	0.2614	I	0.2720
3/8 x 24	0.3750	0.3479	0.3239	Q	0.3320
7/16 x 20	0.4375	0.4050	0.3762	25/64	0.3906
1/2 x 20	0.5000	0.4675	0.4387	29/64	0.4531
9/16 x 18	0.5625	0.5264	0.4943	33/64	0.5156
5/8 x 18	0.6250	0.5889	0.5568	37/64	0.5781
3/4 x 16	0.7500	0.7094	0.6733	11/16	0.6875
7/18 x 14	0.8750	0.8286	0.7874	13/16	0.8125
1 x 14	1.0000	0.9536	0.8978	15/16	0.9375

Table 3—Metric Thread Dimensions

Bolt Diameter (in mm)	Distance Between Threads (in mm)	Diameter of Drill (in mm)	Bolt Diameter (in mm)	Distance Between Threads (in mm)	Diameter of Drill (in mm)
M 2	0.4	1.6	M 22	2.5	19.5
M 2.2	0.45	1.75	M 24	3	21
M 2.5	0.45	2.05	M 27	3	24
			M 30	3.5	26.5
M 3	0.5	2.5			
M 3.5	0.6	2.9	M 33	3.5	29.5
M 4	0.7	3.3	M 36	4	32
M 4.5	0.75	3.7	M 39	4	35
			M 42	4.5	37.5
M 5	0.8	4.2			
M 6	1	5	M 45	4.5	40.5
M 8	1.25	6.8	M 48	5	43
M 10	1.5	8.5	M 52	5	47
M 12	1.75	10.2	M 56	5.5	50.5
M 14	2	12	M 60	5.5	55
M 16	2	14	M 64	6	58
M 18	2.5	15.5	M 68	6	62
M 20	2.5	17.5			

☐ 3. Drill tap hole to proper size.

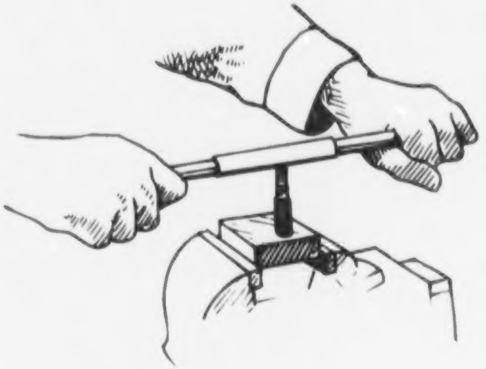
☐ 4. Place cutting tap in tap wrench.

☐ 5. Place tap in hole keeping the tap as straight as possible.

☐ 6. Apply cutting oil to tap.

☐ 7. Press down on tap wrench with equal pressure on both sides.

Figure 1



☐ 8. Make two complete turns with tap.

☐ 9. Check to see that the tap is straight. If tap is not straight, remove it and start again.

Note: A slight amount of pressure will be required to get the tap to start straight.

☐ 10. Tap the hole by turning the tap wrench clockwise one half of a turn then counterclockwise one quarter of a turn.

☐ 11. After the hole is tapped, remove the tap by turning the wrench counterclockwise.

Note: Hold on to the tap wrench to prevent it from falling on the floor.

☐ 12. When finished, clean tools and put away, or go on to next procedure.

Procedure

Restoring internal threads

☐ 1. Place workpiece in vice.

☐ 2. Select proper thread chasing/rethreading tap and place in tap wrench.

☐ 3. Place tap into hole keeping tap as straight as possible.

☐ 4. Apply cutting oil to tap.

☐ 5. Start turning tap into threads, keeping the tap as straight as possible. If the starting threads of the hole are damaged, it may be necessary to exert some downward pressure to restart the tap.

☐ 6. Run the tap through all of the threads of the hole, reversing the tap a 1/4 turn for every full turn forward to break loose any metal chips from the cutting process.

☐ 7. Remove tap from hole and inspect restored threads. Determine if further work is needed.

☐ 8. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ____________________

____

____

Objective 22

Job Sheet 4—Install a Thread Insert

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Drilled to remove damaged threads	______
• Tapped hole for receiving insert	______
• Installed insert	______
• Removed insert tang	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Electric drill motor
- Tap*
- Tap wrench
- Thread insert*
- Insert installation tool*
- Vise
- Workpiece
- Tap drill*

* Components may be included together as an "insert kit."

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Place workpiece in vice.

☐ 2. Select proper size tap drill as recommended by the insert kit instructions.

☐ 3. Drill out damaged threads.

☐ 4. Tap the insert receiving threads with kit-supplied tap and a tap wrench. Clear chips from hole when finished running the tap.

☐ 5. Install insert in newly tapped hole using a slight downward pressure as the installation tool is turned.

Note: Some tools have an adjustable collar to prevent skipping a thread while installing.

☐ 6. Wind insert into hole until it is one-half turn below the surface.

Note: Make sure the insert isn't longer than hole before installing insert. On blind holes, keep insert one or two threads from the bottom.

☐ 7. Remove drive tang from insert. (On some, disengage installation tool from tang, rotate tool 90°, and tap down on the tang sharply to break tang off. Use the tang removal tool where supplied.)

☐ 8. Remove workpiece from vise.

☐ 9. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

640

Unit Contents

Student Components

Student Page

Objective Sheet 2B-3

Information Sheet 2B-5

Assignment Sheets

1—Describe Characteristics of Pipe, Tubing, and Hose 2B-23
2—Identify Fittings and Threads 2B-29

Job Sheets

1—Replace a Skive Hose End 2B-31
2—Replace a No Skive Hose End 2B-33

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and discuss the characteristics of lines, fittings, and couplings, and replace hose ends. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to lines, fittings, and couplings with their definitions.
2. Name applications that use lines, fittings, and couplings.
3. Discuss the hazards of incorrect or improperly installed lines, fittings, and couplings.
4. Distinguish between correct and incorrect rules for safe use and installation of lines, fittings, and couplings.
5. Select true statements concerning characteristics of pipe.
6. Complete statements concerning characteristics of metal tubing.
7. Select true statements concerning characteristics of nylon and plastic tubing.
8. Complete statements concerning characteristics of flexible hose.
9. Identify types of fittings commonly used with pipe.
10. Distinguish between types of fittings commonly used with tubing.
11. Distinguish among types of hose ends.
12. Identify common configurations of hose ends.
13. Identify common valves.
14. Match types of accessories with their special applications.
15. Complete statements concerning the installation of pipe or tubing.
16. Distinguish between correct and incorrect installation of hose.
17. Describe characteristics of pipe, tubing, and hose. (Assignment Sheet 1)
18. Identify fittings and threads. (Assignment Sheet 2)

Objective Sheet

19. Replace a skive hose end. (Job Sheet 1)

20. Replace a no skive hose end. (Job Sheet 2)

643

Information Sheet

Objective 1

Terms and definitions

a. **Burst pressure**—Amount of pressure that a component is designed to withstand before breaking

b. **Coupler**—Non-threaded fitting used to join lines that are frequently disconnected

c. **Department of Transportation (DOT)**—Federal agency that sets transportation standards, which affect vehicle design and manufacturing

d. **Fitting**—Device for connecting lines to components or to other lines

e. **Hose**—Flexible line that can readily bend for ease of installation or to accommodate movement of components

f. **Hose end**—Fitting attached onto a hose

g. **Joint Industrial Council (JIC)**—Organization that promotes industrial standards

h. **Line**—Any tube, flexible or rigid, through which fluid or gas is conducted from one component to another

i. **American or national standard tapered thread (NPT)**—Standard thread that creates a seal with pipe sealing compound

j. **National taper pipe thread or dryseal American (NPTF)**—Standard thread that creates a seal without pipe sealing compound

k. **Pipe**—Rigid line that is not intended to be bent or shaped

l. **Pounds per square inch (PSI)**—Standard pressure measurement

m. **Skive**—To remove the outer covering on a hose

n. **Tube**—Semi-rigid line that is customarily bent into a desired shape

o. **Working pressure**—Maximum amount of pressure that a component is expected to build when functioning

Objective 2

Applications that use lines, fittings, and couplings

a. Air brake systems

b. Air conditioning systems

c. Cooling and heating systems

d. Fuel systems

e. Hydraulic systems

f. Lubrication systems

Objective 3

Hazards of incorrect or improperly installed lines, fittings, and couplings

a. Fittings thrown off at high speed

b. High velocity fluid discharge

c. Explosion or burning of the conveyed fluid

d. Electrocution from high voltage electric power lines or other sources of electricity

e. Contact with suddenly moving or falling objects that are to be held in position or moved by the conveyed fluid

f. Dangerously whipping hose

g. Contact with conveyed fluids that may be hot, cold, toxic, or otherwise harmful

h. Sparking or explosion caused by static electricity buildup

i. Sparking or explosion while spraying paint or flammable liquids

Objective 4

Rules for safe use and installation of lines, fittings, and couplings

a. Always use nonconductive lines in installations exposed to high voltage electricity.

b. Always use lines and fittings that have maximum working pressures equal to or exceeding the maximum system pressure.

c. Always select lines and fittings by working pressure, not burst pressure.

d. Always use lines capable of withstanding the system's vacuum in suction applications.

e. Always use lines and fittings capable of withstanding the system's temperature extremes. Carefully route lines that pass near hot parts.

f. Always use lines and fittings that are compatible with the fluids they will convey.

g. Always use the size of lines and fittings specified by the manufacturer.

h. Always use lines and fittings that can withstand any elements to which they are exposed.

i. Never use a bend radius smaller than a line's specified minimum bend radius.

j. Always protect lines and fittings from wear or damage.

k. Always use correct length of lines.

l. Always keep lines clean, as required by their specific application.

m. Always inspect lines, fittings, and couplings before installation.

n. Always eliminate all air, pressurize, and then test a system from a safe position after installation.

o. Regularly inspect, test, and replace lines, fittings, and couplings at specified intervals.

p. Never use a line, fitting, or coupling for any purpose other than its intended application

Objective 5

Characteristics of pipe

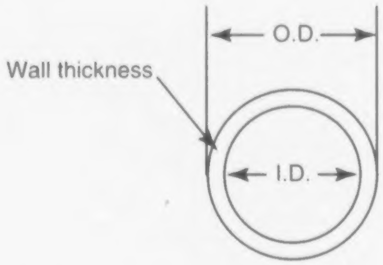
a. Material

- Use seamless, cold-drawn mild steel for hydraulic applications.
- Galvanized pipe is not an acceptable material in heavy equipment applications because its zinc coating can come off and damage components.

b. Size (see Table 1)

- Pipe size is typically stated by nominal inside diameter.

Figure 1



- The wall thickness of any given size of pipe is stated as a "schedule number." The higher the schedule number, the thicker the wall. Schedule 40 is most common.

- Each size of pipe will also have a different working pressure and burst pressure.

Table 1—Sizes and Pressures of Steel Pipe

Nominal Size	Pipe O.D.	Inside Diameter Schedule 40	Working Pressure (Burst Pressure) Schedule 40
1/8	.405	.269	3500 (20,200)
1/4	.540	.364	2100 (19,500)
3/8	.675	.493	1700 (16,200)
1/2	.840	.622	2300 (15,600)
3/4	1.050	.824	2000 (12,900)
1	1.315	1.049	2100 (12,100)
1 1/4	1.660	1.380	1800 (10,100)
1 1/2	1.900	1.610	1700 (9,100)
2	2.375	2.067	1500 (7,800)

Objective 6

Characteristics of metal tubing

a. Material

- Copper—Generally used in systems with low pressure and little vibration; does not withstand heat or flaring well

- Aluminum—Generally used in systems with low pressure; flares and bends better than copper

- Steel—Used in systems that build high amounts of pressure; two types of steel tubing are commonly available, seamless and electric welded

b. Size (see Table 2)

- Size is indicated by (actual) outside diameter and wall thickness.
- Wall thickness is sometimes described as:
  - Thin wall (low pressure)
  - Standard (high pressure)
  - Thick wall (very high pressure)

Table 2—Sizing of Metal Tubing

Tubing O.D.	Wall Thickness	Tubing I.D.
1/8	0.028	0.069
	.032	.061
	.035	.055
3/16	0.032	0.1235
	.035	.1175

Objective 7

Characteristics of nylon and plastic tubing

a. Pressures

- Plastic—Low pressure (150 psi typical)
- Nylon—High pressure (800 to1400 psi)

b. Size is stated in terms of:

- Tubing O.D.
- Minimum burst pressure

Table 3—SAE Nylon Tubing for Air Brake Systems and Air Control Gauge Lines

SAE Number	Tubing Type	Tubing O.D.
SAE J844 Type 3A	Single wall extruded nylon	1/8", 1/4", 5/16"
SAE J844 Type 3B	Extruded nylon inner tube, one layer of open ply nylon fiber reinforcement, and a nylon outer cover	3/8", 1/2", 5/8" 3/4"
NT-100	Single wall extruded plastic (250 psi working pressure) meet DOT FMVSS 571.06	
Polyvinyl Chloride (PVC)	Extruded single wall Max working pressure 45-65 psi	1/4", 5/16", 3/8", 1/2"
Polyethylene (PE)	Extruded single wall Max working pressure 100-160 psi	1/4", 5/16", 3/8", 1/2"

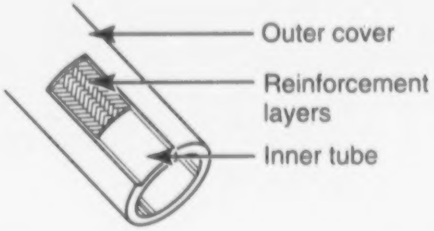
Objective 8

Characteristics of flexible hose

a. Flexible hose is made of three main layers.

- Inner tube
- Reinforcement layer(s) may consist of one or more sublayers.
  - Low pressure applications use fiber braid.
  - High pressure applications use wire braid.
- Outer cover

Figure 2—Flexible hose construction



b. Size is stated in terms of several factors:

- Inside diameter
- Working pressure
- Construction

Note: The SAE number is a useful, simplified way of describing a hose's construction.

649

Table 4—SAE Hose Types

SAE Number	Inner Tube	Reinforcement	Cover
SAE 100R1	Synthetic Rubber	1 High Tensile Steel	Synthetic Rubber
SAE 100R2	Synthetic Rubber	2 Wire Braids 2 Spiral Plies and 1 Wire Braid	Synthetic Rubber
SAE 100R3	Synthetic Rubber	2 Textile Braids	Synthetic
SAE 100R4	Synthetic Rubber	Braided Textile Fibers/ Spiral Body Wire	Synthetic
SAE 100R5	Synthetic Rubber	1 Textile Braid 1 High Tensile Steel Wire Braid	Cotton Braid
SAE 100R6	Synthetic Rubber	1 Textile Braid	Synthetic Rubber
SAE 100R7	Thermoplastic	Synthetic Fiber	Thermoplastic
SAE 100R8	Thermoplastic	Synthetic Fiber	Thermoplastic
SAE 100R9	Synthetic Rubber	4 Spiral Plies Wrapped in Alternating Directions	Synthetic Rubber
SAE 100R10	Synthetic Rubber	4 Spiral Plies of Heavy Wire Wrapped in Alternating Directions	
SAE 100R11	Synthetic Rubber	6 Spiral Plies of Heavy Wire Wrapped in Alternating Directions	Synthetic Rubber

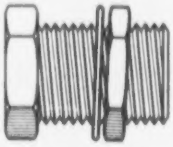
Objective 9

Types of fittings commonly used with pipe

Note: Copper, brass, and nylon/plastic fittings are used for low pressure (less than 300 psi) applications; steel/iron (coated or black) fittings are for high pressure applications.

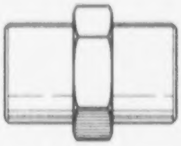
a. Anchor connector

Figure 3



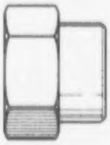
b. Coupling

Figure 4



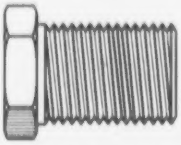
c. Reducer coupling

Figure 5



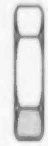
d. Bushing

Figure 6



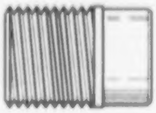
e. Lock nut

Figure 7



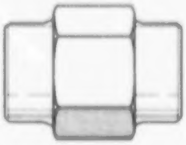
f. Square-head plug

Figure 8



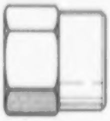
g. Union

Figure 9



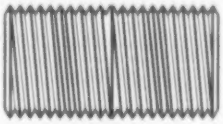
h. Cap

Figure 10



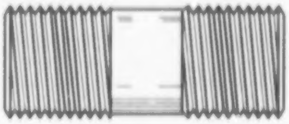
i. Close nipple

Figure 11



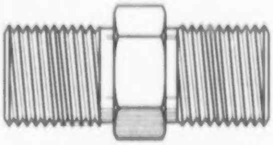
j. Long nipple

Figure 12



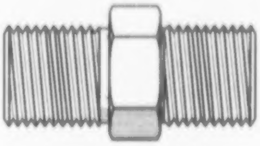
k. Hex nipple

Figure 13



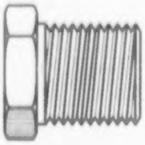
l. Hex nipple reducer

Figure 14



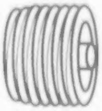
m. Hex head plug

Figure 15



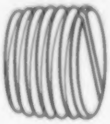
n. Countersunk hex head plug

Figure 16



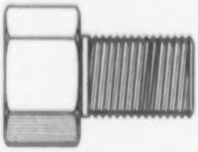
o. Slotted head plug

Figure 17



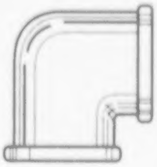
p. Adapter

Figure 18



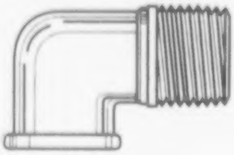
q. 90° union elbow

Figure 19



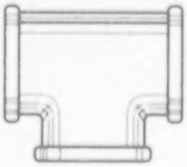
r. 90° street elbow

Figure 20



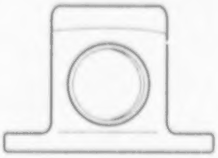
s. Union tee

Figure 21



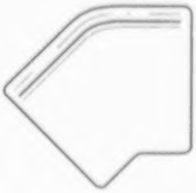
t. Drop-ear 90° elbow

Figure 22



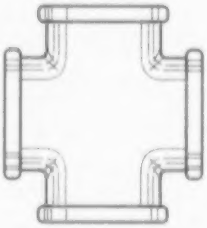
u. 45° female elbow

Figure 23



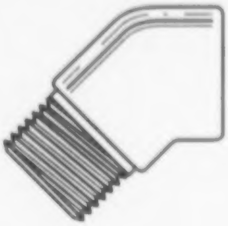
v. Cross

Figure 24



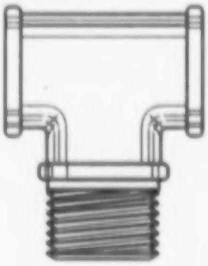
w. 45° street elbow

Figure 25



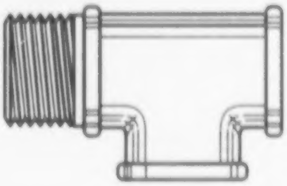
x. Male branch tee

Figure 26



y. Street tee

Figure 27



Objective 10

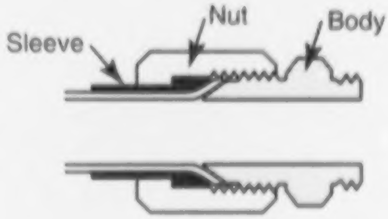
Types of fittings commonly used with tubing

a. Flared fittings

- The end of the tube is flared to mate with a fitting.
- The most common flare angle is 37° (JIC). Low pressure applications sometimes use a 45° flare.
- A standard three-piece flared fitting consists of:
    - — A body which abuts the flared end of the tube
    - — A sleeve which fits over the tube
    - — A nut which fits over the sleeve and is threaded onto the body

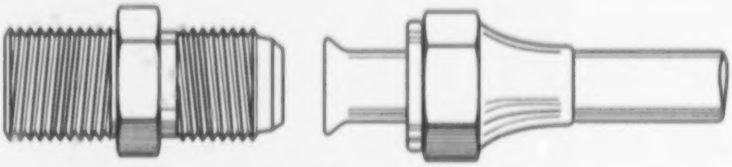
653

Figure 28—Standard three-piece flared fitting



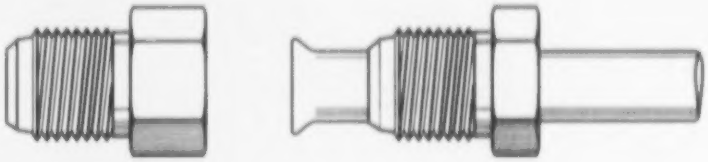
- A two-piece flared fitting eliminates the sleeve by using a tapered nut.

Figure 29



- An inverted flared fitting has an internally-flared, threaded female receptacle which is connected to a male thread nut.

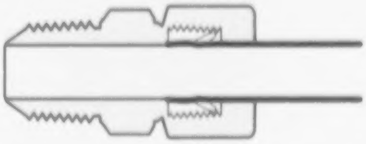
Figure 30



b. Flareless fittings

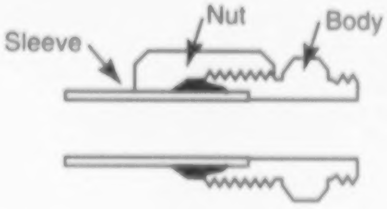
- Have the advantages of being reusable and not requiring flaring tools for installation
- In compression or swage-type fittings, the tubing material is compressed to form a build-up of tubing material around a retaining ring. This ring holds the fitting on the tubing

Figure 31



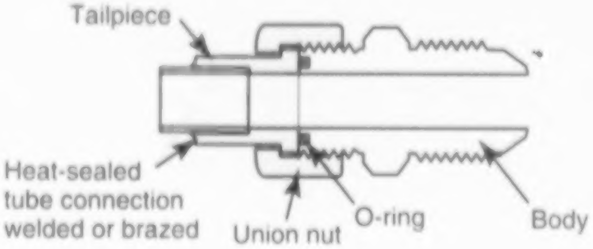
- In ferrule or bite-type fittings, a retaining ring is compressed onto the tube. The ring "bites" into the tubing. The primary difference between swage and bite fittings is that the swage-type displaces the tubing to conform around the retaining ring, while the bite-type cuts into the tubing.

Figure 32


Nut
Body
Sleeve

- In o-ring or braze-on fittings, the fitting is brazed or welded onto the end of the tubing.

Figure 33

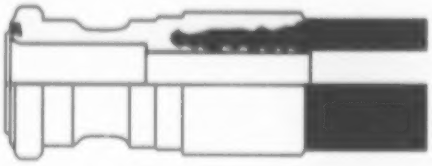

Tailpiece
Heat-sealed
tube connection
welded or brazed
Union nut
O-ring
Body

Objective 11

Types of hose ends

a. **Permanent**—The fitting is crimped or swaged onto the hose

Figure 34

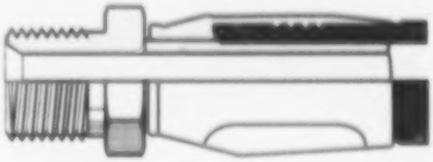


b. **Reusable**

- No skive
  - — The hose cover is not removed.
  - — The hose-end nipple is inserted into the hose.

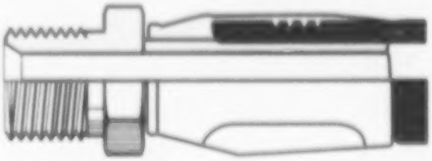
- A socket (sleeve) is screwed or pushed onto the hose-end to clamp it onto the hose.

Figure 35



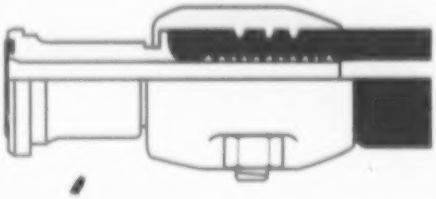
- Skive
  - The hose cover is removed (skived) before installation of the hose end.
  - Otherwise, the installation is the same as the no-skive.

Figure 36



- Clamp on
  - A barbed hose-end nipple is inserted into hose, and a clamp is bolted onto the hose to provide grip.
  - Used only in low-pressure systems

Figure 37

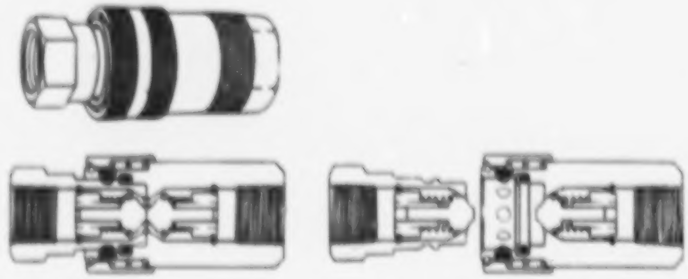


c. **Quick disconnect couplers**

- Are convenient devices for fastening hoses which are frequently disconnected and reconnected

- Because they are self sealing, they minimize fluid loss when disconnecting lines.

Figure 38



Coupled

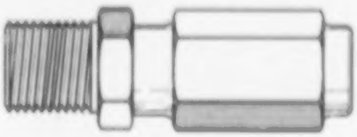
Uncoupled

Objective 12

Common configurations of hose ends

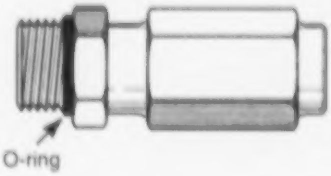
a. Male pipe

Figure 39



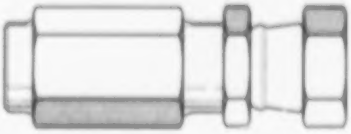
b. Straight thread o-ring

Figure 40



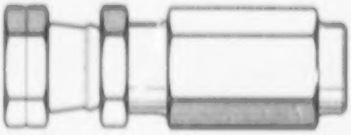
c. 37° swivel

Figure 41



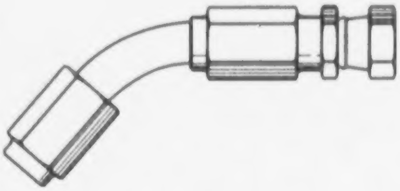
d. 45° swivel

Figure 42



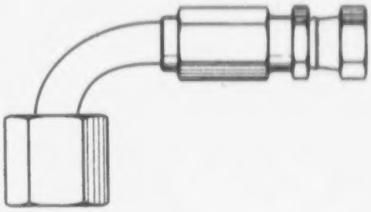
e. 37° swivel, 45° elbow

Figure 43



f. 37° swivel, 90° elbow

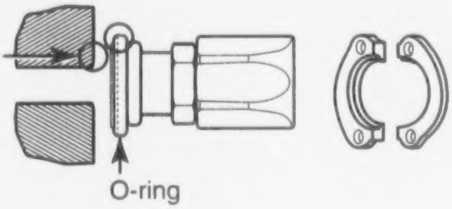
Figure 44



g. Flange o-ring seal

Note: Four-bolt flange fittings may use either split flanges, as shown in the illustration, or single-piece flanges.

Figure 45

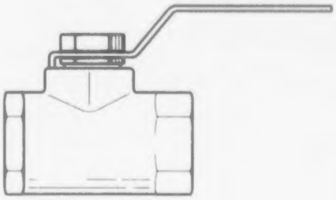


Objective 13

Common valves

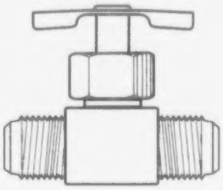
a. Ball valve

Figure 46



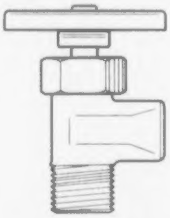
b. Needle valve

Figure 47



c. Stem valve

Figure 48

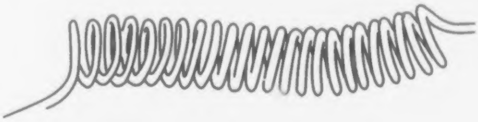


Objective 14

Types of accessories and their special applications

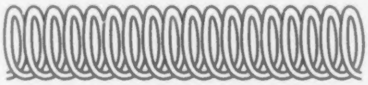
a. **Coil**—Connects lines between units such as tractor-trailer combinations

Figure 49



b. **Spring guard**—Protects exposed hose

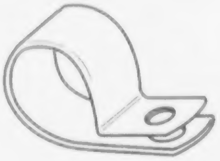
Figure 50



659

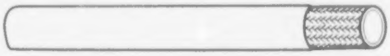
c. **Hose support clamp**—Secures and protects long lines

Figure 51



d. **Firesleeve**—Protects hoses from extreme heat

Figure 52

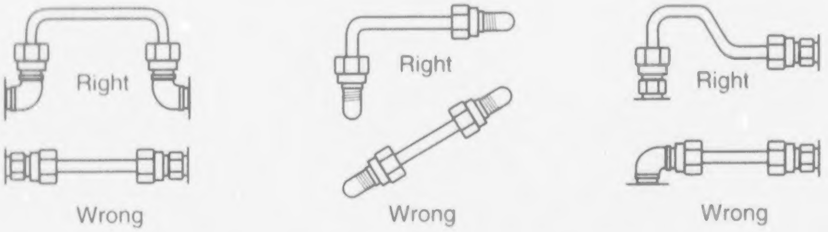


Objective 15

Installation of pipe or tubing

a. Avoid straight-line hookups, which do not allow adequate expansion and contraction.

Figure 53



b. Use the fewest and simplest bends possible.

c. Support long runs of tubing.

d. Avoid interference with operator controls.

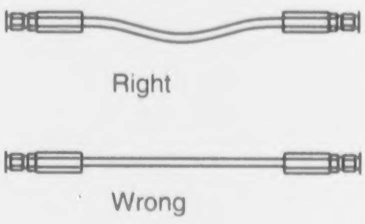
Information Sheet

Objective 16

Installation of hose

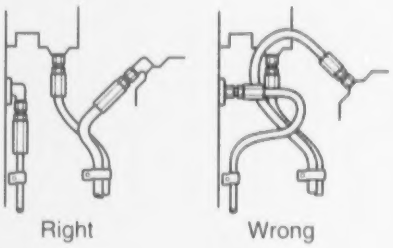
a. Avoid taut hose.

Figure 54


Right
Wrong

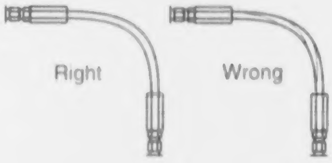
b. Avoid loops.

Figure 55


Right
Wrong

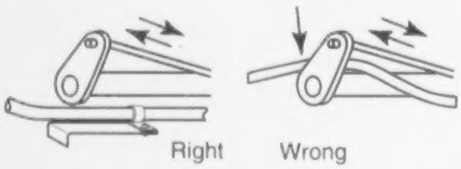
c. Avoid twisting.

Figure 56


Right
Wrong

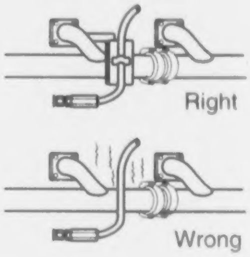
d. Avoid rubbing.

Figure 57


Right
Wrong

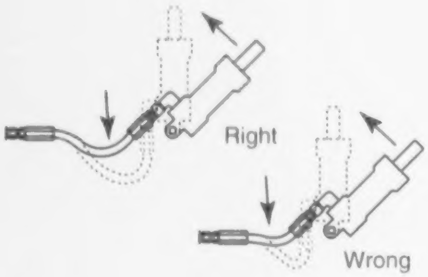
e. Avoid contact with heat.

Figure 58


Right
Wrong

f. Avoid sharp bends.

Figure 59


Right
Wrong

Objective 17

Assignment Sheet 1—Describe Characteristics of Pipe, Tubing, and Hose

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

Basic Skills

Reading Mathematics Critical Thinking

Introduction

As a diesel equipment technician, you will frequently service, repair, and replace lines. Because they often function under high pressure, the failure of a line can cause severe equipment damage and possibly the injury or death of the technician or the equipment operator. The diesel technician, therefore, must be able to identify types of lines and their essential features. The exercise in this assignment sheet will help you to develop those skills.

Materials List

- Pipes
- Tubes
- Hoses

Directions

Your instructor will provide you with samples of lines. Identify and examine them and write your answers in the blanks provided.

Part A: Refer to Table 1 at the end of this assignment sheet to answer questions regarding pipe.

1. **Steel Pipe 1**

    a. What is the pipe's nominal size? ______________________

    b. What is the pipe's inside diameter? ______________________

    c. What is the pipe's outside diameter? ______________________

2. **Steel Pipe 2**

   a. What is the pipe's nominal size? ______________________

   b. What is the pipe's inside diameter? ______________________

   c. What is the pipe's outside diameter? ______________________

3. **Steel Pipe 3**

   a. What is the pipe's nominal size? ______________________

   b. What is the pipe's inside diameter? ______________________

   c. What is the pipe's outside diameter? ______________________

Part B: Refer to Table 2 to answer questions regarding tubing.

1. **Tube 1**

   a. What material is the tube made of? ______________________

   b. What is the tube's size (outside diameter)? ______________________

   c. What is the tube's inside diameter? ______________________

   d. What is the tube's wall thickness? ______________________

   e. Is the tube thin wall, standard, or thick wall? ______________________

2. **Tube 2**

   a. What material is the tube made of? ______________________

   b. What is the tube's size (outside diameter)? ______________________

   c. What is the tube's inside diameter? ______________________

   d. What is the tube's wall thickness? ______________________

   e. Is the tube thin wall, standard, or thick wall? ______________________

3. **Tube 3**

   a. What material is the tube made of? ______________________

   b. What is the tube's size (outside diameter)? ______________________

   c. What is the tube's inside diameter? ______________________

   d. What is the tube's wall thickness? ______________________

   e. Is the tube thin wall, standard, or thick wall? ______________________

Part C: Refer to Table 3 to answer questions regarding hose.

1. **Hose 1**
   a. What is the hose's size (internal diameter)? ____________________
   b. What material is the hose's inner tube made of? ____________________
   c. What material is the hose's outer layer made of? ____________________
   d. List the hose's reinforcement layers. ____________________
   ____
   e. What is the hose's SAE number? ____________________
2. **Hose 2**
   a. What is the hose's size (internal diameter)? ____________________
   b. What material is the hose's inner tube made of? ____________________
   c. What material is the hose's outer layer made of? ____________________
   d. List the hose's reinforcement layers. ____________________
   ____
   e. What is the hose's SAE number? ____________________
3. **Hose 3**
   a. What is the hose's size (internal diameter)? ____________________
   b. What material is the hose's inner tube made of? ____________________
   c. What material is the hose's outer layer made of? ____________________
   d. List the hose's reinforcement layers. ____________________
   ____
   e. What is the hose's SAE number? ____________________

Assignment Sheet 1

Table 1—Sizes and Pressures of Steel Pipe

Nominal Size	Pipe O.D.	Inside Diameter Schedule 40	Working Pressure (Burst Pressure) Schedule 40
1/8	.405	.269	3500 (20,200)
1/4	.540	.364	2100 (19,500)
3/8	.675	.493	1700 (16,200)
1/2	.840	.622	2300 (15,600)
3/4	1.050	.824	2000 (12,900)
1	1.315	1.049	2100 (12,100)
1 1/4	1.660	1.380	1800 (10,100)
1 1/2	1.900	1.610	1700 (9,100)
2	2.375	2.067	1500 (7,800)

Table 2—Sizing of Tubing

Tubing O.D.	Wall Thickness	Tubing I.D.
1/8	0.028	0.069
	.032	.061
	.035	.055
3/16	0.032	0.1235
	.035	.1175

665

Table 3—SAE Hose Types

SAE Number	Inner Tube	Reinforcement	Cover
SAE 100R1	Synthetic Rubber	1 High Tensile Steel	Synthetic Rubber
SAE 100R2	Synthetic Rubber	2 Wire Braids 2 Spiral Plies and 1 Wire Braid	Synthetic Rubber
SAE 100R3	Synthetic Rubber	2 Textile Braids	Synthetic
SAE 100R4	Synthetic Rubber	Braided Textile Fibers/ Spiral Body Wire	Synthetic
SAE 100R5	Synthetic Rubber	1 Textile Braid 1 High Tensile Steel Wire Braid	Cotton Braid
SAE 100R6	Synthetic Rubber	1 Textile Braid	Synthetic Rubber
SAE 100R7	Thermoplastic	Synthetic Fiber	Thermoplastic
SAE 100R8	Thermoplastic	Synthetic Fiber	Thermoplastic
SAE 100R9	Synthetic Rubber	4 Spiral Plies Wrapped in Alternating Directions	Synthetic Rubber
SAE 100R10	Synthetic Rubber	4 Spiral Plies of Heavy Wire Wrapped in Alternating Directions	
SAE 100R11	Synthetic Rubber	6 Spiral Plies of Heavy Wire Wrapped in Alternating Directions	Synthetic Rubber

Objective 18

Assignment Sheet 2—Identify Fittings and Threads

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

Basic Skills

Reading Critical Thinking

Introduction

As a diesel equipment technician, you will frequently service, repair, and replace fittings and threads. Because they often function under high pressure, the failure of threads or a fitting can cause severe equipment damage and possibly the injury or death of the technician or the equipment operator. The diesel technician, therefore, must be able to identify types of threads and fittings and their features.

Materials List

- Fittings

Directions

Your instructor will provide you with examples of good/bad pipe threads and various fittings. Identify each thread fitting and write your answer in the space provided.

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________

Objective 19

Job Sheet 1—Replace a Skive Hose End

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Removed hose ends from old hose correctly	______
• Measured replacement hose and cut to correct length	______
• Skived hose correctly	______
• Installed new hose end securely and correctly	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Wrenches as required
- Hose ends (skive type)
- Replacement hose (matched to hose ends)
- Tape measure
- Tool to cut hose
- Vise
- Knife

Caution: Follow all shop safety procedures throughout this procedure.

Procedure

☐ 1. Remove the hose ends from the old hose. Pull off or unscrew the socket (sleeve). Then remove the hose-end nipple.

☐ 2. Measure replacement hose and cut to length.

☐ 3. Remove the outer covering where the sleeve is to be placed on the hose using appropriate cutting tool.

☐ 4. Lubricate the end of the hose and place the sleeve on the hose.

☐ 5. Place the sleeve and hose assembly into the vise.

☐ 6. Repeat for the other end.

☐ 7. Have your instructor check your work.

☐ 8. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 20

Job Sheet 2—Replace a No Skive Hose End

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Removed hose ends from old hose correctly	______
• Measured replacement hose and cut to correct length	______
• Installed new hose end securely and correctly	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Wrenches as required
- Hose ends (no skive type)
- Replacement hose (matched to hose ends)
- Tape measure
- Tool to cut hose
- Vise

Caution: Follow all shop safety procedures throughout this process.

Procedure

☐ 1. Remove the hose ends from the old hose. Pull off or unscrew the socket (sleeve). Then remove the hose-end nipple.

☐ 2. Measure replacement hose and cut to length.

☐ 3. Lubricate the end of the hose and place the sleeve on the hose.

☐ 4. Place the sleeve and hose assembly into the vise.

☐ 5. Repeat for the other end.

☐ 6. Have your instructor check your work.

☐ 7. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

671

Unit Contents

Student Components

Student Page

Objective Sheet 3B-3

Information Sheet 3B-5

Job Sheets

1—Install a Radial Lip Seal 3B-23
2—Remove and Install an Engine Oil Seal and Wear Sleeve 3B-27
3—Install a Packing 3B-29
4—Replace a Formed Gasket 3B-31
5—Replace a Formed-In-Place Gasket 3B-33
6—Remove and Install a Camshaft Friction Bearing 3B-35
7—Remove and Install an Antifriction Bearing 3B-39
8—Clean and Pack an Antifriction Bearing 3B-41

Objective Sheet

Unit Objective

After completing this unit, the student should be able to distinguish between types of seals and bearings and remove and replace basic seals and bearings. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to seals and bearings with their definitions.
2. List purposes of seals.
3. Distinguish between the basic categories of seals and their uses.
4. Complete statements concerning common seals and their descriptions.
5. Match the parts of a lip seal with their descriptions.
6. Complete statements concerning common materials for seals.
7. Distinguish between types of packings.
8. Describe causes of sealing failure.
9. Complete statements concerning guidelines for installing seals.
10. Distinguish between types of gaskets.
11. Describe common gasket materials and their uses.
12. Select true statements concerning guidelines for installing gaskets.
13. List functions of bearings.
14. Distinguish between basic categories of bearings.
15. Identify major types of bearings.
16. Identify parts of an antifriction bearing.
17. Distinguish between load forces on bearings.
18. List conditions that determine load-carrying capacity of bearings.
19. Select from a list common materials used for bearings.
20. List reasons for bearing failures.

Objective Sheet

21. Distinguish between correct and incorrect bearing maintenance procedures.

22. List items to look for when inspecting bearings.

23. Install a radial lip seal. (Job Sheet 1)

24. Remove and install an engine oil seal and wear sleeve. (Job Sheet 2)

25. Install a packing. (Job Sheet 3)

26. Replace a formed gasket. (Job Sheet 4)

27. Replace a formed-in-place gasket. (Job Sheet 5)

28. Remove and install a camshaft friction bearing. (Job Sheet 6)

29. Remove and install an antifriction bearing. (Job Sheet 7)

30. Clean and pack an antifriction bearing. (Job Sheet 8)

Information Sheet

Objective 1

Terms and definitions

a. **Arbor press**—Type of equipment used to press-fit bearings, gears, and other equipment

b. **Babbit**—Soft metal (alloy of lead, tin, antimony, and other metals) commonly used to line bearings

c. **Back-up ring**—Ring installed behind an o-ring or other seal to hold it in place

d. **Bushing**—Full, round, plain bearing

e. **Compress**—To reduce in size or volume by squeezing

f. **Counterbore**—Enlarged area around a seal or shaft to allow room for a seal or o-ring

g. **Elastomeric**—Synthetic, elastic substance that resembles rubber

h. **Friction**—Resistance to motion between two bodies in contact

i. **Gasket**—Thin material placed between surfaces of stationary parts to prevent leakage

j. **Journal**—That part of a shaft, axle, or spindle that turns in a bearing

k. **O-ring**—Simple seal with a round cross-section

l. **Press fit**—Tight fit between mating parts; must be "pressed" into place

m. **Races**—Two hardened steel rings

n. **Seal**—Material shaped to leakproof moving parts

o. **Sealant**—Type of gasket applied as a liquid, paste, or spray

p. **Spindle**—Small shaft or axle

q. **Splines**—Ribbed or tooth-like portions of seals, bushings, pulleys, and other equipment

Information Sheet

Objective 2

Purposes of seals

a. To retain lubricants or liquids

b. To exclude dirt, water, and other contaminants

c. To separate dissimilar fluids (such as lubricating oil and water)

d. To confine pressure

Objective 3

Basic categories of seals and their uses

a. **Dynamic seals**

- Used to make leakproof connection between **moving** parts
- Commonly used on shafts and rods, compression packings, and piston rings

b. **Static seals**

- Used to make leakproof connection between **fixed** parts
- Commonly used as gaskets, o-rings, packings, and sealers

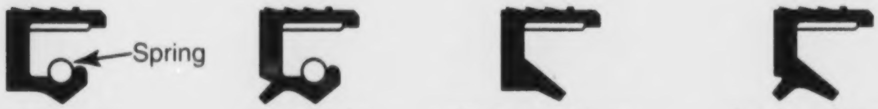
Objective 4

Common seals and their descriptions

a. **Radial lip seals**

- Most common type used on shafts
- May be single, dual, or multi-lip designs
- May be spring-loaded or springless
- Designs vary depending on whether seal is to be used with grease- or oil-lubricated bearings

Figure 1



Single Lip Oil Seal (SLO)

Dual Lip Oil Seal (DLO)

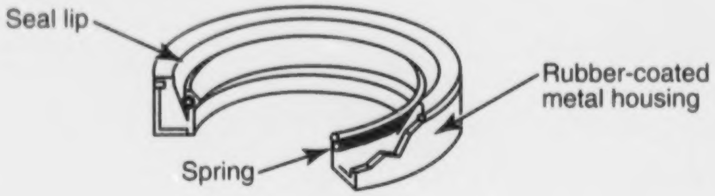
Single Lip Grease Seal (SLG)

Dual Lip Grease Seal (DLG)

©1996 Federal-Mogul Corporation. Reproduced with permission.

- Seal is enclosed in a metal or synthetic case that may also have a rubber or synthetic coating that aids in sealing.

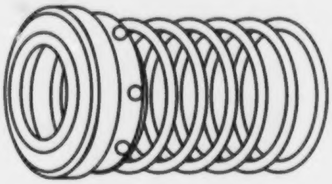
Figure 2


Seal lip
Rubber-coated metal housing
Spring

b. **Mechanical seals**

- Commonly used on pumps and hydraulic systems
- Have a spring to force the seal in place
- Face materials may be carbon, ceramic, bronze, tungsten, silicon, and other synthetics.

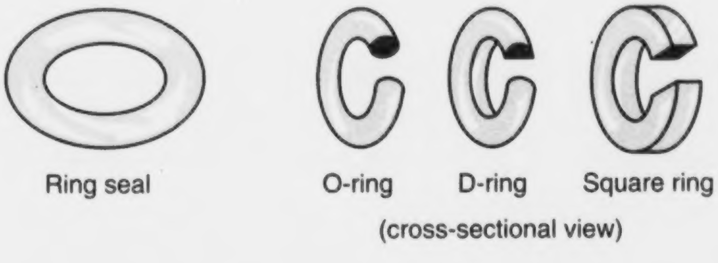
Figure 3



c. **Ring seals**

- May be soft or hard rings

Figure 4


Ring seal
O-ring
D-ring
Square ring
(cross-sectional view)

— Soft ring seals are pliable and include o-rings and similar flexible variations.

— Hard ring seals may be made of metal or various synthetic materials such as Teflon® and nylon.

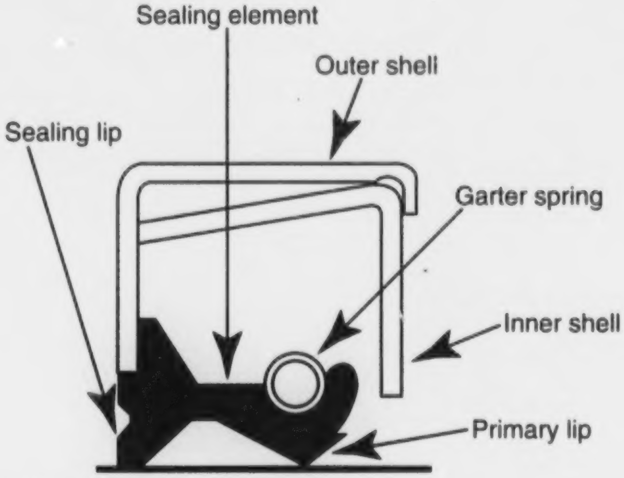
Examples: Piston rings, hook-type ring oil seals (used in automatic transmissions), square Teflon® or nylon ring seals.

- Commonly used between a moving part and a stationary part
- May also have a backup ring for excess pressure

Objective 5

Parts of a lip seal

Figure 5



Drawing courtesy of Chicago-Rawhide

a. **Outer shell (case)**—Outer, cup-shaped, rigid structure that acts as a protective cover for the sealing element and holds the installed seal in place

b. **Inner shell (case)**—Rigid, cup-shaped component placed inside the outer seal case; can function as a reinforcing member, shield, spring retainer, or lip-clamping device

c. **Sealing element**—Flexible elastomeric "working" component that rides against the shaft

d. **Primary lip**—Flexible elastomeric part that contacts the rotating surface

e. **Secondary lip**—Short, non-spring-loaded part used to exclude contaminants; faces opposite direction of primary lip

f. **Garter spring**—Coiled wire spring with its ends connected; used for maintaining a sealing force between the sealing element and sealing surface

678

Objective 6 | Common materials for seals

	Material	Advantages	Disadvantages	Notes
Non-Synthetics	Leather	Good dry running capabilities; compatible with most lubes and solvents	Poor compatibility with water; poor heat resistance; expensive	Not in common use; nitrile is usually substituted
	Felt (wool)	Excludes dirt and dust well; retains grease efficiently	Cannot confine light oil; absorbs water, which may cause shaft rusting	May be plain or laminated with synthetic surface; nitrile is commonly substituted
Synthetics	Nitrile	Good oil/grease compatibility; good low temp and swell characteristics; low cost	Poor compatibility to some synthetic oils and extreme pressure (EP) lubes; does not have excellent heat resistance	Most common material used today; mixture of two synthetic rubbers; color varies from gray-black to shiny jet black
	Polyacrylates	Good compatibility with most oils, including EP lubes; higher heat capabilities than nitrile	Low compatibility with water; limited low temp capability; poor dry running capability; higher cost than nitrile	Color is generally black; similar in appearance to nitrile
	Silicone	Wide temperature range; high lubricant absorbency; very flexible	Easily damaged during installation; poor compatibility with EP lube additives and oxidized oil; higher cost than nitrile	Color is generally red, orange, gray, or blue; feels very soft and flexible
	Flouroelastomers (including Viton)	Wide temperature range; compatible with wide range of fluids that destroy other synthetics; very long life	Expensive	Color is usually brown to black; may also be blue or green
	P.T.F.E. (Teflon®)	Excellent dry running capabilities; low coefficient of friction; excellent resistance to most chemicals, including hydrocarbons and oxygenated blends	Poor abrasion resistance to dirty environment; high thermal expansion; easy to damage during installation	Color is usually white

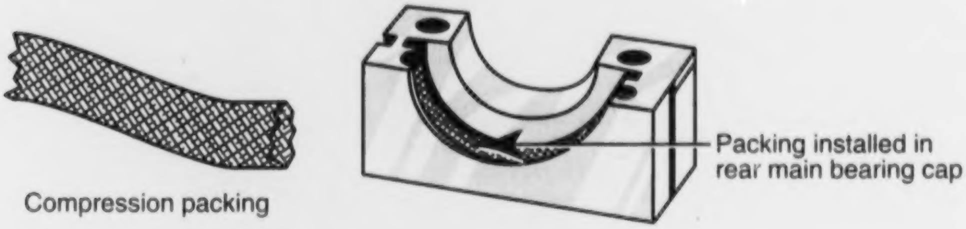
Objective 7

Types of packings

a. Compression packings

- Create a seal when squeezed into place

Figure 6



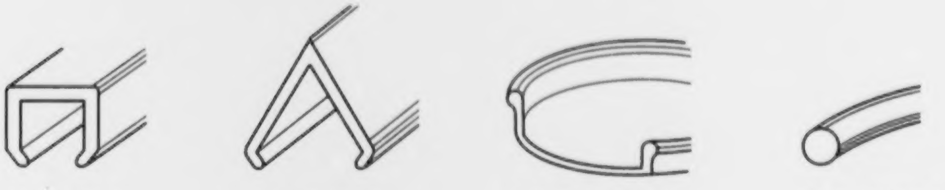
Compression packing

- Available as a "rope" or partially preformed sections
- Commonly made of fabric, metal, or plastic; may also be surface-coated with graphite or Teflon®

b. Molded compression packings

- Depend on pressure from the fluid being sealed to seal the packing against the wearing surface
- May be U-, V-, cup-, or ring-shaped

Figure 7



U-shaped V-shaped Cup-shaped Ring-shaped

- Open side is installed towards fluid pressure
- Commonly made of rubber or other rigid synthetic material
- Commonly used in hydraulic cylinders

Objective 8

Causes of sealing failure

Note: All seals will eventually fail and begin to leak with normal use. However, seals that fail prematurely are usually caused by one of the following:

a. **Improper installation techniques or careless handling**—Could result in nicked or cut sealing surfaces, scratched shaft, distorted or cocked seal, or damaged garter spring

b. **Incorrect seal used for application**

   - Includes seals that are the wrong size; that are used in systems with excessive speeds, temperatures, or pressures; or that use fluids incompatible with the sealing material
   - Could result in seals that are brittle, cracked, hardened, excessively worn, spongy, or blown-out

c. **Misalignment of shaft to bore**—Commonly results in excessive wear on one side of the seal

d. **Shaft or bore excessive roughness, scratches, burrs, or dirt**—Can result in excessive wear to the shaft, bore, and/or seal

Objective 9

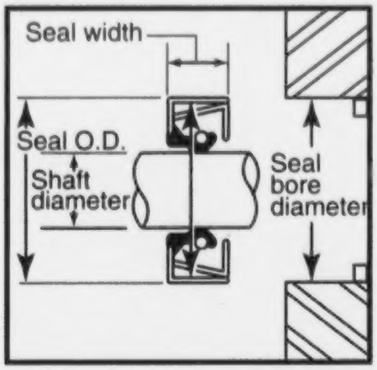
Guidelines for installing seals

a. Remove the old seal carefully. Take care when prying out the old seal not to scratch the housing. Sometimes you need a special puller.

b. Inspect the bore and shaft for nicks and burrs. File off any burrs that could cut the new seal.

c. Check shaft and bore dimensions to make sure they match the seal specifications.

Figure 8



Drawing courtesy of Chicago-Rawhide

d. Excessively worn or grooved shafts may be fitted with wear (repair) sleeves to create a new seal running surface. These require a special installation tool.

e. Never reuse old or damaged seals.

f. Make sure the new seal faces in the correct direction; usually the lip faces the lubricant or fluid to be retained.

g. Prelubricate the sealing element with the same lubricant being retained prior to installation.

h. Use the correct tool to install the seal. These include an arbor press, soft-face hammer, specially-made seal installer, or old bearing cup. Apply force evenly around the outer edge to avoid cocking the seal.

i. Check to see that the seal is fully seated and aligned in its bore. The manufacturer may specify how deep the seal must be installed.

j. Check and adjust the fluid level after installing a seal, and check for leaks.

k. When installing packing, make sure it is firmly seated and compacted (depending on its composition) in the groove according to the seal manufacturer's directions. Check the equipment manufacturer's service manual for trimming specifications.

l. After installing a ring seal (o-ring), smooth the seal with your fingers to make sure it is not twisted.

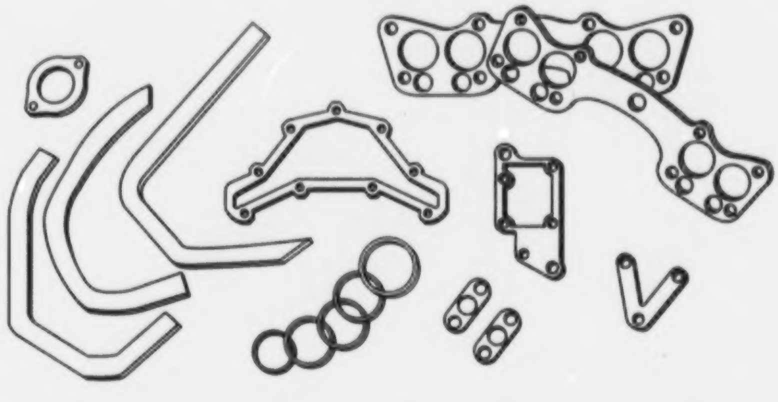
Objective 10

Types of gaskets (static seals)

a. Formed gaskets

- Made from various solid materials and come in a variety of shapes and sizes

Figure 9—Examples of gaskets



- Made to fit the shape and hole arrangement by the manufacturer or cut to fit by the installer

b. Formed-in-place gaskets (sealants)

- Made from various chemicals
- Used increasingly where paper and cork gaskets were previously used
- May be sprayed on, brushed on, or applied with a spatula or putty knife out of a tube
- Several types
    - RTV (room-temperature vulcanizing) sealants form a rubber-like, waterproof seal by absorbing moisture from the air. Silicone is a common RTV sealant.
    - Anaerobic sealants are used to make formed-in-place gaskets where heat or harsh chemicals are present. They cure in the absence of air, beginning as soon as the parts are put together, allowing time to properly position the mating surfaces.

Objective 11

Common gasket materials and their uses

a. Paper gaskets—Used on water outlets, water pumps, timing covers, fuel pumps, and some carburetors

b. Neoprene (synthetic rubber) gaskets—Used with valve covers, which are periodically removed for valve adjustments; are reusable

c. Cork gaskets—Commonly used as valve cover, transmission, and engine oil pan gaskets; limited use because of their brittleness and tendency to shrink

d. Steel gaskets—Used in high temperature areas; some head gaskets are made of steel

Note: Steel gaskets are used only with cast iron heads and blocks, never with aluminum.

e. Asbestos/combination gaskets—Made with asbestos or other heat-resistant material; used in high-temperature areas

f. Teflon® gaskets—Used in high-temperature areas

Objective 12

Guidelines for installing gaskets

a. General guidelines for replacing gaskets

- Select the correct type and size gasket made of the correct material.
- Remove all of the old gasket. Scrape or brush with a wire brush gently to avoid damaging the part. The smallest nick or dent can result in an imperfect seal, and then leakage can occur. Finish cleaning the surfaces to be sealed by wiping clean and dry with a shop cloth and solvent.

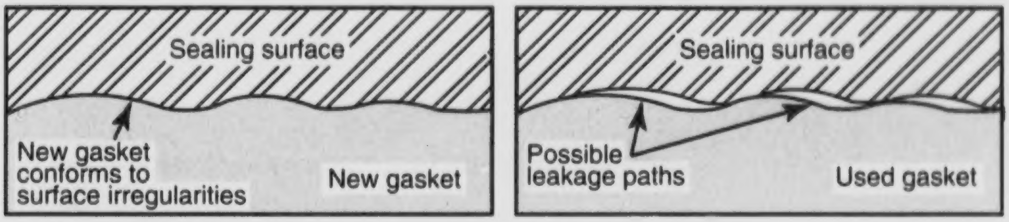
Caution: Spray cleaners can damage skin and eyes. Always follow the safety instructions on the container label.

- Hand-start fasteners, then tighten in the recommended torque sequence to the correct torque. Do not overtighten fasteners. Overtightening can damage metal parts and break the formed gasket or can squeeze the formed-in-place gasket sealer away from the mating surfaces.
- Complete gasket replacements by checking for leaks. If a gasket leaks, it must be replaced and the fasteners retightened to the correct torque.

b. Guidelines for using formed gaskets

- Gaskets should not be reused. As a gasket is installed and the mating surfaces are tightened together, the gasket is compressed. The gasket will not return to its original thickness when removed. Therefore, it cannot be reused because it will not compress and seal properly.

Figure 10



Drawings courtesy of Fel-Pro Inc.

- Store gaskets flat in the packages and away from extreme temperatures and humidity.
- Always inspect gaskets carefully before installing them. Be sure they are free of dents, cracks, bends, or debris. A badly bent gasket cannot be corrected without damaging the gasket.
- Handle gaskets carefully. Do not force a gasket to fit. If it becomes cracked or torn, it can no longer be used and should be thrown away.

c. Guidelines for using formed-in-place gaskets

- Make sure that the equipment manufacturer allows the use of a formed-in-place gasket for the application.
- Check the RTV or anaerobic sealer to make sure it is appropriate for the specific application. Sealer-made gaskets generally may be used except in high-temperature and fuel areas.
- Some sealers used for making formed-in-place gaskets produce vapors that interfere with the operation of electronic sensors on the equipment, so be sure to check the equipment manufacturer's service manual.
- Use a low-volatile RTV on equipment having oxygen sensors and use it sparingly. Equipment with a computer-controlled ignition has an oxygen sensor.
- Follow the sealer manufacturer's instructions about the time to wait before tightening fasteners. The curing time for RTV sealers is about 10 minutes, for anaerobic sealers about 15 minutes.
- Always use the bead size specified by the sealer manufacturer.

Objective 13

Functions of bearings

a. Support the moving part

b. Reduce friction

c. Reduce wear

d. Provide a replaceable wear surface

Objective 14

Basic categories of bearings

a. **Friction or plain bearing** (also called bushing)

- Provides a **sliding** contact between mating surfaces
- Advantages—Low cost, quiet operation, requires less space
- Disadvantages—High friction operation, requires more frequent lubrication because they cannot be packed

b. **Antifriction bearing**

- Provides a **rolling** contact between mating surfaces
- Advantages—Low friction operation, can be packed to reduce frequency of lubrication, many designs
- Disadvantages—Higher cost, noisier operation, requires more space

Information Sheet

Objective 15

Major types of bearings

a. **Friction or plain bearings**

- Split—Two halves
- Sleeve or plain bushing—Full round (one-piece)

Figure 11

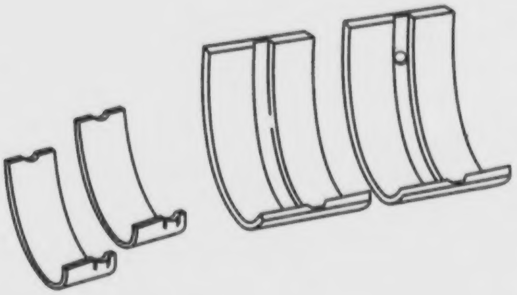
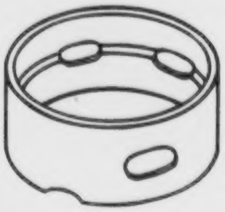


Figure 12



b. **Antifriction bearings**

- Ball
- Straight roller

Figure 13

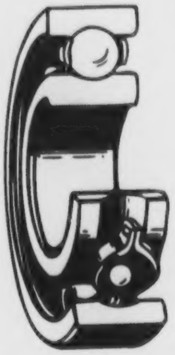
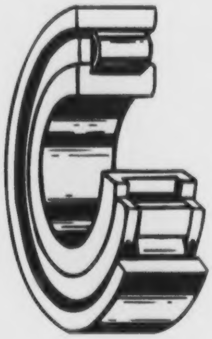
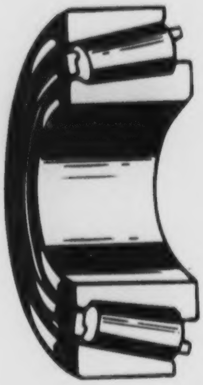


Figure 14



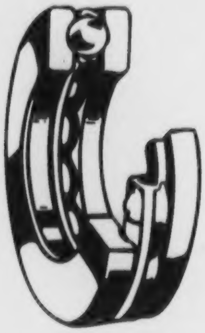
- Tapered roller

Figure 15



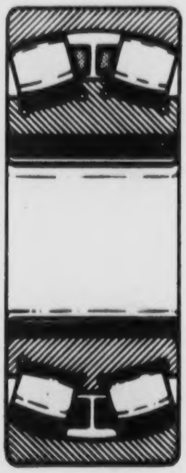
- Ball thrust

Figure 16



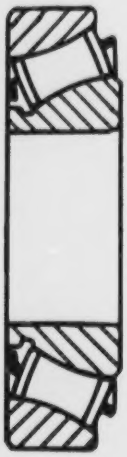
- Spherical roller (barrel roller)

Figure 17



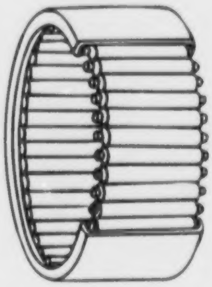
- Concave roller

Figure 18



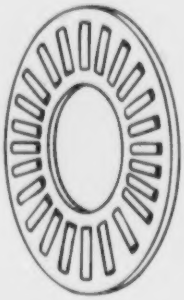
- Radial-load needle

Figure 19



- Thrust-load needle

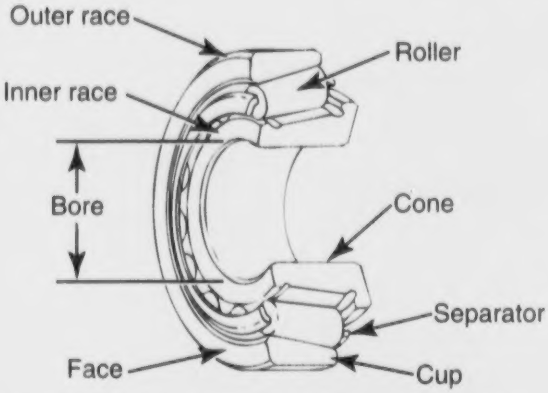
Figure 20



Objective 16

Parts of an antifriction bearing

Figure 21


Outer race
Roller
Inner race
Bore
Cone
Separator
Face
Cup

Used with permission of Deere and Company, Moline, Illinois.

688

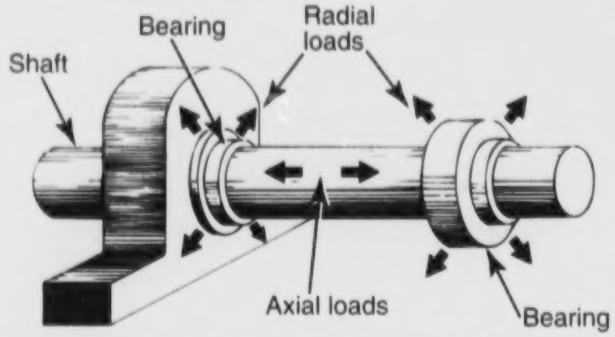
Objective 17

Load forces on bearings

a. **Axial or thrust load forces**—Directed endways or horizontal to the shaft

b. **Radial load forces**—Directed sideways or perpendicular to the shaft

Figure 22



Reproduced by permission of Deere & Company, ©1992. Deere & Company. All rights reserved

Objective 18

Conditions that determine load-carrying capacity of bearings

a. Size of bearing

b. Number of rolling elements

c. Types of races

Note: It is very important that a replacement bearing have the same load-carrying capacity as the original.

Objective 19

Common materials used for bearings

a. Steel alloys

b. Other metals and metal alloys—Cast iron, babbit, copper-lead, nickel, aluminum, etc.

c. Synthetic rubbers and plastics

Objective 20

Reasons for bearing failures (listed in order of frequency)

a. Dirt

b. Improper assembly

c. Misalignment

d. Insufficient lubrication or inferior lubricants

e. Overloading

f. Corrosion

g. Inferior material

h. Incorrect grooving

i. Incorrect clearance

Note: Always inspect damaged bearings to determine cause of failure so that cause can be remedied before replacing bearings.

Objective 21

Bearing maintenance procedures

a. Work with clean approved tools in clean surroundings.

b. Clean outside of housings before exposing bearings.

c. Handle bearings with clean, dry hands.

d. Work on a metal or metal-covered bench.

e. Properly support bearing when removing it from a shaft to prevent damage.

f. Treat a used bearing as carefully as a new one, until the used one is proven to be defective.

g. Use clean solvents and flushing oils.

h. Lay bearings out on a clean surface.

i. Protect disassembled bearings from dirt and moisture.

j. Wipe bearings, if necessary, only with clean, lint-free rags.

k. Thoroughly clean the inside of housings before installing bearings.

l. Install new bearings as they come from the package, without washing, if they are received in a sealed container.

m. Keep lubricants clean when applying them, and cover the containers when not in use.

n. Don't spin uncleaned or dry bearings.

o. Don't spin any bearing with compressed air.

p. Don't use the same container for both cleaning and final rinse of used bearings.

q. Use the correct type and amount of lubricant.

Objective 22

Items to look for when inspecting bearings

a. External

- Cracked races
- Dented seals
- Broken or damaged separators
- Broken or damaged balls or rollers
- Brownish blue or bluish black color caused by overheating

b. Internal

- Pitted, scratched, or flaked balls, rollers, and races on separable bearings
- Visible pits or scratches on nonseparable bearings
- Clicking or sticking when outer race is rotated

Objective 23

Job Sheet 1—Install a Radial Lip Seal

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	____
• Cleaned and prepared shaft and bore properly	____
• Lubricated and coated seal properly	____
• Installed seal using correct tool and without damaging seal, shaft, or bore	____
• Checked and tested installation properly	____
• Demonstrated quality work	____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Appropriate service manual
- Shop towels (lint free)
- Basic hand tool assortment
- Seal installation tools recommended in appropriate service manual
- Emery cloth
- Sealant, if required

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Clean the shaft or bore area and inspect for damage.

☐ 2. File or stone any burrs or bad nicks, and polish with fine emery cloth to a ground finish.

☐ 3. Clean area and remove all metal particles.

☐ 4. Lubricate the lips of the seal and the shaft to ease installation, using the system fluid being used.

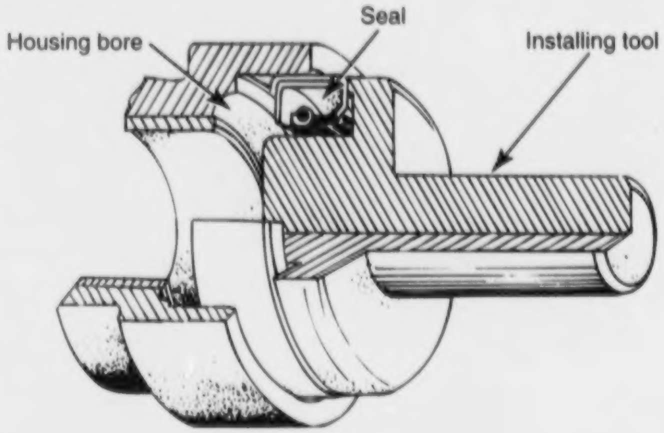
Note: On seals with single lips, the lip should normally face in toward the system lubricant.

☐ 5. Check to see if the seal manufacturer recommends a sealant on the outside of the seal housing. This may or may not be required.

☐ 6. Install the seal according to the procedure in the manufacturer's service manual.

Note: The use of a factory specified installation tool may be required. This is very important with pressed-in seals. If a seal driving tool is not available, use a circular ring such as an old bearing race that contacts the seal case near the outer diameter, or use a square wooden block. Do not use sharp tools, and never press on the sealing lip; press only the outer metal case.

Figure 1



☐ 7. Protect the sealing lip when installing the seal over sharp corners of shafts, keyways, or splines by using installing cones (Figure 2) or sleeves (Figure 3).

Note: Shim stock can also be used to protect seals when installing them over sharp edges such as shaft splines. Place rolled plastic shim stock over the sharp edge, then pull it out after the seal is in place.

Figure 2

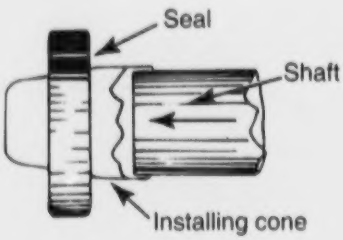
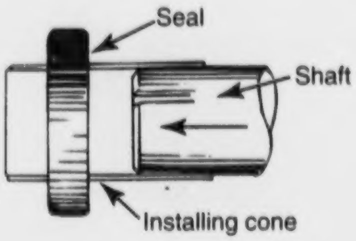
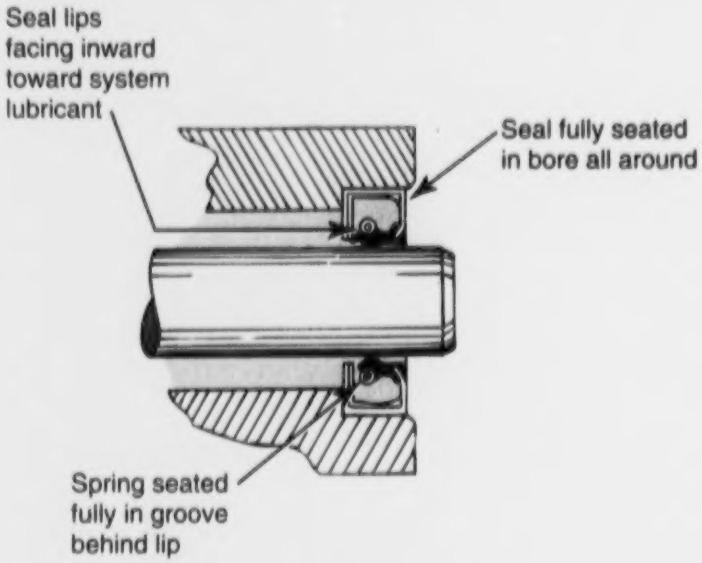


Figure 3



☐ 8. Drive the seal in evenly to prevent "cocking" of the seal.

Figure 4


Seal lips facing inward toward system lubricant
Seal fully seated in bore all around
Spring seated fully in groove behind lip

☐ 9. Always check the unit by hand after assembly for free operation (before starting up the system, if possible).

Note: Prevent dirt and grit from falling on shafts and being carried into the seal which can quickly damage the seal and score the shaft.

☐ 10. Run in new lip type seal; check for leaks.

Note: When a new lip type seal is installed on a clean shaft, a break-in period of a few hours is required to seat the seal lip with the shaft surface. During this period, slight seepage may occur. After proper seating, the seal should perform without any measurable leakage.

☐ 11. Obtain instructor's initials here ______ when finished with installation and checking.

☐ 12. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 24

Job Sheet 2—Remove and Install an Engine Oil Seal and Wear Sleeve

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Follow safety rules throughout procedure	______
• Removed seal housing and seal housing gasket properly	______
• Removed seal from seal housing properly	______
• Checked and properly prepared housing bore, wear sleeve, and crankshaft flange for reinstallation	______
• Installed wear sleeve to service manual specifications using correct tool	______
• Installed and aligned seal housing and seal housing gasket properly	______
• Installed oil seal to manufacturer's specifications using correct tool	______
• Demonstrated quality work	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Appropriate service manual
- Clean shop towels (lint free)
- Basic hand tools
- Seal removing tool
- Seal installing tool
- Wear sleeve installing tool
- Engine oil seal
- Wear sleeve

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Remove rear main oil seal housing from engine.

☐ 2. Remove seal and wear sleeve using the tools and procedure recommended in the service manual for the engine you are servicing.

☐ 3. Check seal housing and crankshaft flange for wear, nicks, and burrs.

☐ 4. Clean and dress area as recommended in the service manual.

☐ 5. Obtain instructor's initials here _____ upon removal of seal and wear sleeve and before proceeding to the next step.

☐ 6. Install the wear sleeve on the crankshaft using the tools and procedure recommended in the service manual.

Note: Avoid heavy pressure or cocking of the wear sleeve.

☐ 7. Obtain instructor's initials here _____ upon installation of wear sleeve and before proceeding to the next step.

☐ 8. Clean crankshaft flange and wear sleeve with clean shop towels.

☐ 9. Install the seal housing and gasket to the cylinder block using the tools and procedure recommended in the service manual.

Note: Pay particular attention to checking the seal housing alignment with the crankshaft.

☐ 10. Obtain instructor's initials here _____ before proceeding to the next step.

☐ 11. Install the oil seal onto the crankshaft and into the seal housing using the tools and procedure recommended in the service manual.

Note: Check manufacturer's recommendations to see if lip should be lubricated and on how far to drive seal into housing.

☐ 12. Obtain instructor's initials here _____ when finished with installation.

☐ 13. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 25

Job Sheet 3—Install a Packing

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Removed old packing and prepared surfaces for reinstallation properly	______
• Prepared and installed new packing properly	______
• Demonstrated quality work	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Wrenches as required
- Pump or other component which uses a seal
- Packings
- Abrasive material such as emery cloth (fine grit)

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Remove the gland or ring that retains the packings.

☐ 2. Remove old packings.

☐ 3. Inspect the shaft surface.

☐ 4. Remove any nicks or scratches with the *fine grit* abrasive material.

☐ 5. Soak the packing in hydraulic oil prior to installation.

☐ 6. Install packings with the cup or V portion toward the pressure.

Note: Packs which are composed of individual rings should be installed with each rotated 180° from the last ring.

☐ 7. Re-install the gland or retaining ring.

☐ 8. Tighten only enough to prevent leakage.

☐ 9. Obtain instructor's initials here ______.

☐ 10. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

698

Objective 26

Job Sheet 4—Replace a Formed Gasket

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Removed old gasket and properly inspected and prepared surfaces for reinstallation	______
• Applied appropriate adhesive according to manufacturer's specifications	______
• Installed gasket properly	______
• Inspected installation and followed up according to equipment and gasket manufacturer's specifications	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Appropriate service manual
- Clean shop towels (lint free)
- Basic hand tools
- Gasket remover
- Degreaser
- Adhesive as required

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Consult service manual for make and model as equipped and gasket manufacturer's instructions for gasket selection and installation.

☐ 2. Remove old valve cover.

☐ 3. Remove old gasket and inspect for any indication of possible causes of leaks.

☐ 4. Gently clean valve cover and head with scraper or wire brush. To clean an aluminum head, use a plastic or other nonmetallic wire brush. On metallic parts, you can also use a chemical gasket remover to manufacturer's specifications. If the cover is metallic, finish cleaning it with a chemical degreaser.

☐ 5. Inspect the mating surfaces and the cover to be sure that no dents, cracks, deep scratches, or other damage or wear might prevent an adequate seal.

☐ 6. Select a new gasket that meets the original equipment manufacturer's specifications.

☐ 7. Inspect the new gasket for damage and check to see that all required openings are free of material.

☐ 8. If necessary to hold the seal in place during installation, apply adhesive to the seal according to service manual and gasket maker's specifications. Sealers are incompatible with valve cover gasket installations and should never be applied to a valve cover gasket.

☐ 9. Put a gasket in place on the valve cover and check for proper fit and alignment.

☐ 10. Put the valve cover on the head and check for proper fit and alignment. Make sure that no foreign objects or parts are between the gasket and the head.

☐ 11. Hand start the bolts and then torque them to the manufacturer's specifications. Avoid overtightening bolts, which can damage the gasket.

☐ 12. Follow the vehicle or gasket manufacturer's instructions for any follow-up procedures such as inspecting for leaks or retightening after a specified interval.

☐ 13. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 27

Job Sheet 5—Replace a Formed-In-Place Gasket

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	_____
• Properly inspected and prepared surfaces for reinstallation	_____
• Selected an appropriate sealant for the application according to manufacturer's specifications	_____
• Applied sealant properly	_____
• Inspected installation and followed up according to equipment and sealant manufacturer's specifications	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Appropriate service manual
- Clean shop towels (lint free)
- Basic hand tools
- Gasket remover
- Degreaser
- Sealant as required

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Your instructor will provide you with parts to be connected with a formed-in-place gasket. If the parts are not installed in the equipment, your instructor will tell you what they are and what kind of equipment they are from. Consult service manual for make and model as equipped and the sealant manufacturer's instructions for gasket selection and installation.

☐ 2. Gently clean the mating surfaces with a scraper or wire brush following the same guidelines outlined in Job Sheet 4.

☐ 3. Inspect the mating surfaces to be sure that no dents, cracks, deep scratches, or other damage or wear might prevent an adequate seal.

☐ 4. Select a sealant that meets the service manual's and sealant manufacturer's specifications for the application. Be sure to check the sealant's expiration date.

☐ 5. Apply a bead of sealant according to the manufacturer's specifications. Make the bead even and complete, making sure that all bolt and stud holes are completely surrounded.

☐ 6. Follow the sealant manufacturer's instructions about how long to wait before tightening fasteners.

☐ 7. Hand start the fasteners and then tighten them evenly in the correct sequence to the torque specified by the manufacturer. Avoid overtightening bolts, which may squeeze the gasket material completely away from the mating surfaces.

☐ 8. Follow the vehicle or gasket manufacturer's instructions for any follow-up procedures such as inspecting for leaks or retightening after a specified interval.

☐ 9. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 28

Job Sheet 6—Remove and Install a Camshaft Friction Bearing

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Removed old bearing properly	______
• Prepared and installed new bearing properly	______
• Oil-hole passages are aligned	______

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Clean shop towels
- Basic hand tools
- Bristle brush
- Cam bearing remover and installer tool
- Shop engine with cam bearings
- Engine stand

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Place engine on blocks or engine stand with the crankshaft chamber facing up.

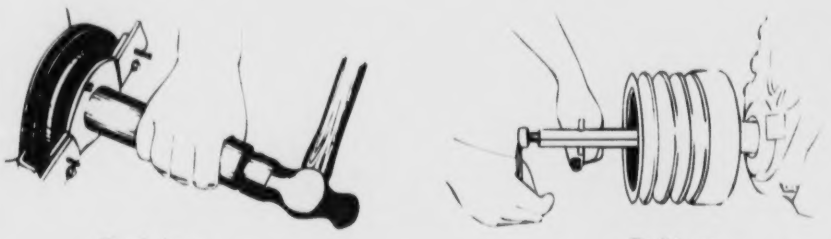
☐ 2. Remove camshaft bearings using the tools and procedure recommended in the service manual for the engine you are servicing.

Note: Some pull the bearing out while others push the bearing out.

☐ a. Select the correct size of puller adapter for each bearing.

Note: Some engines may have cam bearings with all the same inside diameter and others may have different sizes.

Figure 1



Push type Pull type

☐ b. Remove the front and rear bearings first; then remove the intermediate bearings.

Note: Some manufacturers recommend pulling intermediate bearings first; then the front and rear.

☐ c. As you remove the bearings, place them in order on a clean work bench.

Note: Keep the old bearing marked for correct positioning in the bore and for correct location to help install the new bearing.

☐ d. Clean the camshaft bearing bores.

☐ e. Clean the oil passages in the block with a bristle brush, and blow out with compressed air.

☐ 3. Install new camshaft bearings.

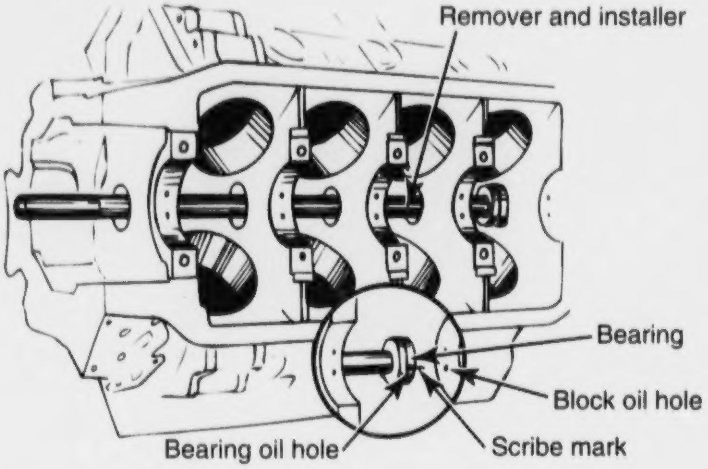
☐ a. Place the new camshaft bearing on a clean shop towel in the order of installation.

☐ b. Check with the service manual on procedure for installing bearing.

☐ c. Place the new bearing on the installer adapter. (Figure 2)

Note: To ease oil hole alignment, mark the adapter in line with the bearing and oil hole and oil passage in the blocks.

Figure 2


Remover and installer
Bearing
Block oil hole
Scribe mark
Bearing oil hole

☐ d. Obtain instructor's initials here _____ before proceeding to the next step.

☐ e. Install the bearing while aligning the oil hole with the alignment mark.

☐ f. Remove installing tool and adapter, and check oil pressure in this assignment.

Note: The bearing oil holes should align with the engine oil holes, and the bearing should not stick out past the block on either side of bore.

☐ g. Install the remaining bearings using the same procedure.

☐ h. Obtain instructor's initials here._____.

☐ 4. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 29

Job Sheet 7—Remove and Install an Antifriction Bearing

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Removed bearing properly with appropriate tool	______
• Installed bearing properly with appropriate tool	______
• Bearing, shaft, and/or bore are in good condition	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Shop towels
- Basic tool set
- Appropriate service manual
- Pullers as recommended (slide hammer, screw type, or hydraulic) or press as recommended
- Vise
- Support blocks

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Remove bearing using pullers or press and the procedure recommended in the service manual for the equipment you are servicing. Be sure to support the bearing races to prevent damage.

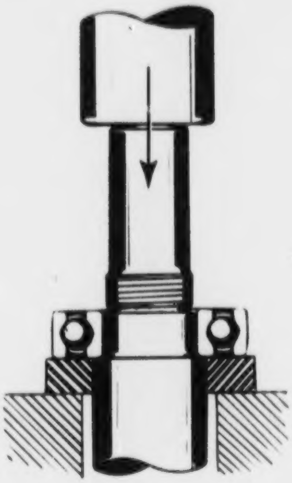


Figure 1—Correct block support

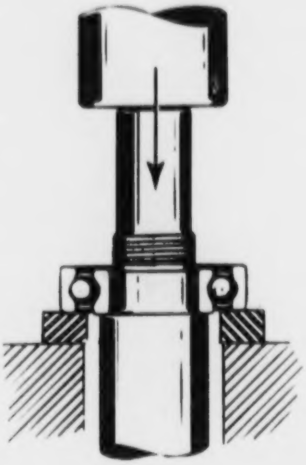


Figure 2—Incorrect block support

☐ 2. Obtain instructor's initials here _____ before proceeding to next step.

☐ 3. Install bearing using tools and procedures recommended in the service manual.

☐ 4. Obtain instructor's initials here _____ before proceeding to next step.

☐ 5. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

Objective 30

Job Sheet 8—Clean and Pack an Antifriction Bearing

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Followed safety rules throughout procedure	______
• Cleaned and inspected bearing properly	______
• Packed bearing properly	______

Basic Skills

Reading · Critical Thinking · Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Clean shop towels
- Basic hand tools
- Recommended cleaning solvent and basket for soaking
- Recommended bearing grease
- Bearing packer

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Place bearings in a basket and let them soak for some time in a recommended cleaning solution.

☐ 2. Agitate the basket several times after bearings have soaked for a period of time.

☐ 3. Remove and inspect the bearings one at a time.

☐ 4. Use a durable brush to loosen the dirt particles.

☐ 5. Complete the cleaning by moving the bearings back and forth in the solvent and then repeat this procedure in a clean solvent bath.

☐ 6. Use compressed air to remove any remaining particles and to remove the solvent.

> Caution: Hold both races of the bearing while cleaning with compressed air. Never allow a race to spin by the force of the air; the ring may explode.

☐ 7. Dip the bearing in light engine oil and gently rotate it a few times.

☐ 8. Place bearing on a clean shop towel to drain off excess oil.

☐ 9. Check the bearing rollers and races for discoloration and for damaged races, seals, separator, balls, or rollers.

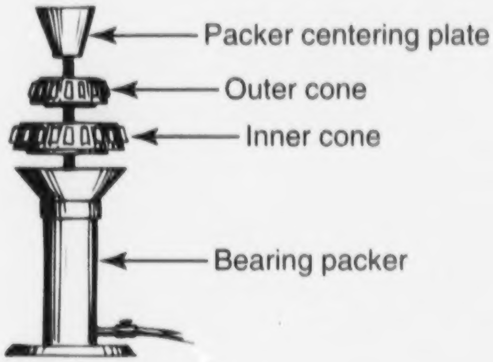
☐ 10. Obtain instructor's initials here _____ before proceeding to next step.

☐ 11. After inspection, if the bearing appears satisfactory, dip the bearing in clean oil and store in greaseproof paper until it is to be installed.

Note: Before some bearings are to be installed, they have to be packed (lubricated) with grease. If this is required, proceed to next step.

☐ 12. Place the clean bearing into the bearing packer.

Figure 1



☐ 13. Unscrew the packer centering plate and install bearing.

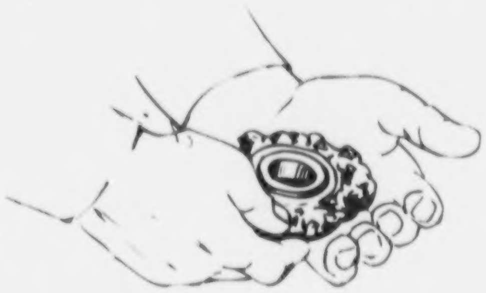
☐ 14. Screw the packer centering plate down and center bearing.

☐ 15. Force the grease through the cones slowly enough to observe when the bearing cage is completely filled with grease.

☐ 16. Remove the cones from the packer, and cover the ends of the rollers with grease.

Note: If a bearing packer is not available, the bearing will have to be packed by hand. Place some grease in one hand, and hold bearing in the other hand. Slowly force the grease into all the spaces in the bearing.

Figure 2



☐ 17. After the bearings have been packed, keep them in a clean, covered area until they are needed.

☐ 18. Obtain instructor's initials here ______.

☐ 19. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Unit Contents

Student Components

Student Page

Objective Sheet 4B-3

Information Sheet 4B-5

Student Supplement

1—API Engine Oil Classification 4B-23

Job Sheets

1—Test for Combustion Leakage into a Cooling System 4B-25
2—Test for Air in a Cooling System 4B-27
3—Clean a Cooling System 4B-29
4—Change Oil and Oil Filter 4B-33

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify and discuss the characteristics of fluids and lubricants and be able to perform basic maintenance on fluid systems. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to fluids and lubricants with their definitions.
2. Distinguish between true and false statements concerning fluid safety rules.
3. Match the basic components of fluid systems with their functions.
4. Distinguish among the common types of filters.
5. Match common additives to fluids with their functions.
6. Select from a list the effects of contaminants in fluid systems.
7. Discuss practices for ensuring fluid system cleanliness.
8. List applications of fluid systems on diesel/heavy duty equipment.
9. Label a diagram showing the flow of fuel through the fuel system.
10. Distinguish between grades of diesel fuel used on diesel/heavy duty equipment.
11. Complete statements concerning alternative fuels that may be used on diesel/heavy duty equipment.
12. Select from a list the correct purpose of a cooling system.
13. Distinguish between effects of a malfunctioning cooling system.
14. Match parts of a liquid cooling system with their functions.
15. Complete statements concerning liquid cooling systems in diesel/heavy duty equipment.
16. List characteristics of a good antifreeze.
17. Complete statements concerning the importance of engine lubrication.
18. List functions of engine oil.

Objective Sheet

19. Match parts of the engine lubrication system with their functions.
20. List characteristics of a good engine oil.
21. Complete statements concerning viscosity.
22. Complete statements concerning the API classification system.
23. Discuss oil maintenance procedures.
24. Complete statements concerning fluids/oils for transmissions and gearboxes.
25. Distinguish between true and false statements concerning fluids for power steering.
26. Select from a list the appropriate locations of filters in hydraulic systems.
27. Identify the types of filter circuits in hydraulic systems.
28. Complete statements concerning chassis lubrication systems.
29. Complete statements concerning chassis grease.
30. Discuss maintenance of chassis lubrication systems.
31. Complete statements concerning batteries.
32. Test for combustion leakage into a cooling system. (Job Sheet 1)
33. Test for air in a cooling system. (Job Sheet 2)
34. Clean a cooling system. (Job Sheet 3)
35. Change oil and oil filter. (Job Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Aeration**—Mixture of air and water

b. **Additives**—Certain properties added to oil to provide extra performance

Examples: SCA—Supplemental Cooling Additive
DCA—Dry Chemical Additive

c. **American Petroleum Institute (API)**—Association that conducts research and provides technical information and services about the petroleum industry

d. **American Society for Testing and Materials (ASTM)**—Association that establishes standard test methods, specifications, and recommended practices for various materials, products, and services

e. **Antifreeze**—Material added to coolant to prevent freezing

f. **Ash**—Solid residue (non-burnable) left when combustible material (such as oil) is burned or oxidized

g. **Contaminant**—Any unwanted material in a fluid or lubricant

Examples: Metal, rust, sand, water (most frequent)

h. **Coolant**—Liquid that absorbs and transfers heat to maintain normal engine operating temperature

i. **Filter**—Device that removes contaminants from fluids or lubricants

j. **Friction**—Resistance to movement between any two objects placed in contact with each other

k. **Gallery**—Pipe or passageway in the engine used to carry engine oil from one area to another

l. **Inhibitor**—Chemical that dissolves in water to form a rustproof film on metal

m. **Micron**—Tiny measurement equal to one millionth of one meter (or approximately forty millionths of an inch)

n. **MIL**—Military specification

o. **Particulate**—Substance made up of minute separate particles

p. **Permanent antifreeze**—Liquid solution containing properties that will not readily boil away

q. **Society of Automotive Engineers (SAE)**—Association that collects and distributes information on vehicle technology

r. **Strainer**—Coarse filter usually designed to prevent large items such as rocks and bolts from entering the system

s. **Viscometer**—Instrument used to measure viscosity

t. **Viscosity**—Measure of a fluid's resistance to flow (at a given temperature)

u. **Volatile**—Readily changed from liquid to vapors at a relatively low temperature

Objective 2

Fluid safety rules

a. Allow the system to cool before working on it.

Note: Fluid temperatures will commonly be in the range of 150°F to 225°F or even higher. These temperatures can cause severe burns.

b. Avoid contact with skin or eyes.

Note: Some fluids are very caustic or corrosive.

c. Remove filter caps and pressure caps slowly to relieve any trapped pressure.

Note: Some fluid systems are capable of pressure buildup in the reservoir from thermal expansion of the fluid caused by a hot day. You may be sprayed with fluid if the pressure is not slowly released.

d. Since many fluids are flammable, treat all fluids as flammable materials.

e. Avoid contact with hot objects such as exhaust manifolds.

f. Wear safety glasses when entering a fluid system at any point.

Objective 3

Basic components of fluid systems and their functions

a. **Reservoir**—Holds the amount of fluid needed for the system to operate correctly

b. **Lines**—Convey the fluid to and from the system's parts

c. **Pump**—Moves the fluid through the system

d. **Filter**—Removes dirt, metal particles, and rust and corrosion from the system fluid or prevents foreign objects from entering system components

Note: Degree of filtration is commonly measured in microns.

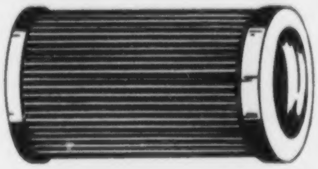
e. **Fluid**—Does the work that system is intended to perform

Objective 4

Common types of filters

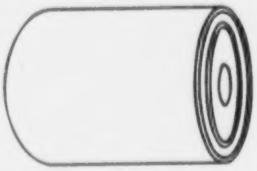
a. **Cartridge filters**—Have a single surface that catches and removes dirt particles larger than the holes in the filter; the surface is made of specially treated micrometric cellulose paper; the fluid passes straight through its tiny holes

Figure 1



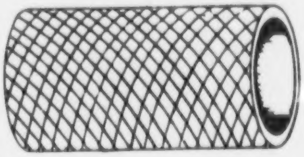
b. **Spin-on filters**—Use a large volume of filter material (usually pleated paper) to trap the particles as the oil passes through

Figure 2



c. **Strainer filters**—Are located at inlets to components (such as oil pans or fuel tanks) to prevent objects such as nuts, bolts, and metal chips from entering the component

Figure 3



Objective 5

Common additives to fluids and their functions

a. Viscosity index improvers—Keep oils at a consistent viscosity in extreme temperatures

b. Anti-wear compounds—Help reduce wear on parts

c. Anti-oxidation compounds—Help reduce rust

d. Corrosion inhibitors—Help reduce corrosion of parts

e. Anti-foam compounds—Help reduce aeration of fluids

Objective 6

Effects of contaminants in fluid systems

a. Reduced component life

Note: Even small amounts of contaminants in the system can wear out a pump in as little as a few hours.

b. Scored internal surfaces resulting in excess leakage and poor performance

c. Clogged internal passages

d. Seized components

e. Poor performance

f. Improper operation

Objective 7

Practices for ensuring fluid system cleanliness

a. Change fluids and filters regularly.

b. Fill systems only with clean fluids.

c. Clean dirt off breather caps and filler plugs before opening the system.

d. Use clean, lint-free towels to wipe dipsticks.

e. Replace worn seals and gaskets to keep dirt from entering the system.

f. Keep work area clean.

Note: This is especially important when disassembling components such as pumps.

g. Clean and flush components before installing them in the system.

Objective 8

Applications of fluid systems on diesel/heavy duty equipment

a. **Power**—Heavy duty equipment generates its power from various fuels, most commonly diesel fuel.

b. **Cooling**—Heavy duty equipment engines may be either air cooled or liquid cooled to keep operating temperatures within acceptable ranges.

c. **Engines**—Engine oils lubricate the moving parts in an engine, protect them from rust and corrosion, and work with the cooling system to keep the engine from overheating.

d. **Transmissions**—Transmission fluids are critical to the functioning of both manual and automatic transmissions.

e. **Gears**—All of the gears in a piece of heavy duty equipment's various components and systems must be properly lubricated to function properly without being damaged.

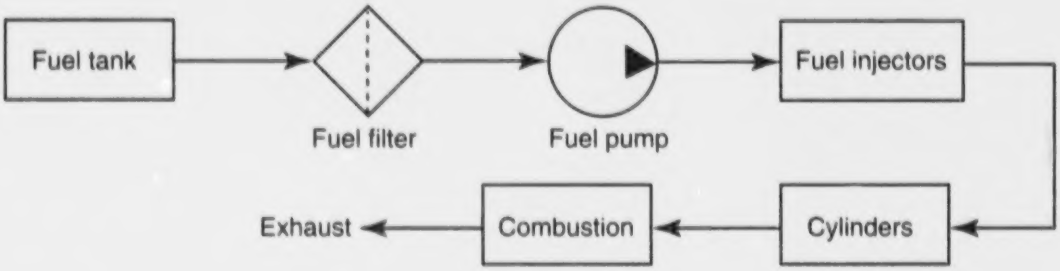
f. **Power steering**—Most power steering systems are fluid assisted.

g. **Hydraulics**—Hydraulic systems derive their power from pressurized fluids.

Objective 9

Flow of fuel through the fuel system

Figure 4



Objective 10

Grades of diesel fuel used on diesel/heavy duty equipment

a. **Grade 1 diesel fuel**

- Used in extremely cold conditions—temperatures below 0° F—or when there are wide variations in loads and speeds
- Because it is less viscous than grade 2 fuel, it remains thin at lower temperatures
- Is volatile

b. **Grade 2 diesel fuel**

- Used in most temperatures and when there are high loads and uniform speeds
- Produces more power than grade 1 fuel
- Is more viscous than grade 1 fuel and, therefore, helps to lubricate and clean parts in the fuel system better
- Is less volatile

Note: Refineries and fuel stations seasonally adjust the content of grade 2 fuel for optimum operation in normal temperature ranges. Also, some kinds of heavy duty equipment are designed with fuel heaters so they can use grade 2 fuel at lower temperatures.

Objective 11

Alternative fuels that may be used on diesel/heavy duty equipment

a. Efforts to reduce the pollutants released into the atmosphere by motor vehicles and heavy equipment have led to the search for alternatives to diesel fuel.

b. Many new emissions standards have taken effect in the 1990s, and as environmental regulations continue to become stricter, the use of alternate fuels will grow.

c. Some of the more promising alternative fuels include:

  - Methane—Is plentiful and cleaner than diesel fuel; however, it does not ignite in a traditional diesel engine; it must be compressed (CNG) and stored under pressure in a compressed gas cylinder or cooled to –258°F to be stored in its liquid form (LNG)
  - Methanol—Is chemically similar to methane, very clean, liquid at room temperature; however, it does not ignite as reliably as diesel fuel or produce as much energy
  - Propane—Clean fuel coming into wider use, especially in agricultural equipment

Objective 12

Purpose of a cooling system—To keep an engine's temperature within its acceptable temperature range

Objective 13

Effects of a malfunctioning cooling system

a. Effects of running too hot

  - Excessive wear of parts
  - Scoring of parts
  - Seizure of moving parts
  - Knocking
  - Burned pistons and valves
  - Lubrication failure
  - Loss of power

b. Effects of running too cold

  - Excessive wear
  - Poor fuel economy
  - Loss of power
  - Accumulation of water and sludge in the crankcase

Objective 14

Parts of a liquid cooling system and their functions

a. **Radiator**—Provides a reservoir for the engine's coolant and releases heat into the atmosphere when the engine is operating

b. **Expansion tank**—Allows for heat expansion of the coolant

c. **Pressure cap**—Relieves pressure from system as coolant heats, lets in air pressure as coolant cools

d. **Fan**—Forces cooling air through radiator core to more quickly dissipate heat

e. **Fan belt**—Transmits power from engine crankshaft to drive fan and water pump

f. **Water pump**—Circulates coolant through the system

g. **Thermostat**—Controls the flow of coolant to the radiator to maintain correct operating temperatures

h. **Hoses**—Flexible connections between the engine and other parts of the cooling system

i. **Coolant**—Medium that carries excess heat from the engine

j. **Coolant filter**—Used in some engines to soften the water, remove dirt, and provide a place for rust inhibitors

Objective 15

Liquid cooling systems in diesel/heavy duty equipment

a. Use a coolant that is a solution of water and an antifreeze made of either ethylene glycol or propylene glycol with chemical additives

b. Coolant ratios

- Typically the ratio of water to antifreeze is 1:1 (50% water, 50% antifreeze).
- Under extreme conditions, that ratio may vary, but if the amount of antifreeze in the system is either too low or too high, the antifreeze loses its effectiveness. In fact, too high a percentage of antifreeze (more than about 65%) not only raises the coolant's freezing point but also lessens its cooling properties.
- Always consult the antifreeze maker's instructions and the service manual for the specific recommended ratios.

Objective 16

Characteristics of a good antifreeze

a. Prevents freezing

b. Inhibits rust and corrosion

c. Is chemically stable

d. Flows readily at all temperatures

e. Resists foaming

f. Does not conduct electricity

Objective 17

Importance of engine lubrication

a. Proper lubrication with the correct oil is critical to the performance and life of an engine.

b. Maintaining the engine oil properly will prolong the engine's life and keep it running at its peak.

c. Allowing the oil pressure to fall too low, using the wrong oil, or not changing the oil at recommended intervals can destroy an engine.

d. At the very least, improper oil maintenance will significantly reduce an engine's performance.

Objective 18

Functions of engine oil

a. Allows parts to move more easily

b. Cushions impact between parts

c. Dissipates heat from the engine bearing contact areas and pistons

d. Reduces wear and corrosion

e. Cleans engine parts

f. Forms seal between pistons, piston rings, and cylinder walls

Objective 19

Parts of the engine lubrication system and their functions

a. **Oil pan**—Provides a reservoir for the engine oil

b. **Oil pump**—Moves oil from the oil pan through a filter and on to all parts that need to be oiled

c. **Oil filter**—Removes abrasive materials from the oil

d. **Oil galleries**—Carry engine oil from one area to another

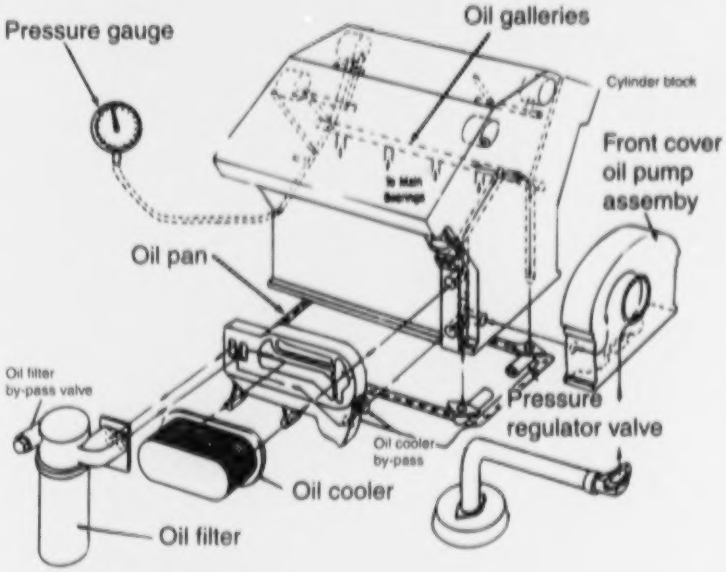
e. **Oil cooler**—Helps dissipate the heat from the engine oil

f. **Pressure regulating valve**—Limits the maximum oil pressure

g. **Pressure gauge**—Indicates oil pressure during engine operation

h. **Thermostat**—Allows for rapid warm-up during initial engine run period

Figure 5—Flow of oil through a typical engine oil system


Pressure gauge
Oil galleries
Cylinder block
Front cover oil pump assemby
To Main Bearings
Oil pan
Oil filter by-pass valve
Pressure regulator valve
Oil cooler by-pass
Oil cooler
Oil filter

Courtesy of Detroit Diesel Corporation

Objective 20

Characteristics of a good engine oil

a. Keeps a thin film on moving parts

b. Flows easily at low temperatures

c. Resists breakdown at high temperatures

d. Resists breakdown after long use

e. Resists corrosion and rusting

f. Resists foaming

g. Prevents carbon buildup

h. Prevents sludge formation

i. Produces low amount of ash

Objective 21

Viscosity

a. Oils vary in viscosity as the temperature changes.

b. Oil becomes more fluid (less viscous) as the temperature rises and less fluid (more viscous) as the temperature falls.

c. Higher viscosity numbers correspond to greater viscosity.

d. Specifications are determined by the time in seconds of flow through a viscometer.

e. Lighter oils for winter use are specified at 0°F and carry a 5W, 10W, or 20W symbol.

f. Heavier oils are specified at 210°F and carry a 20, 30, 40, or 50 viscosity number.

g. Compounded or multigrade oils behave as lighter oils at low temperatures and as heavier oils at high temperatures.

Examples: 10W-30, 15W-40

Objective 22

API classification system

a. Represents a joint effort of API, SAE, and ASTM to clarify and standardize oil specifications and qualities

b. Indicates specifically the type of protection that the oil provides and the applications for which it is appropriate

c. Diesel equipment uses class C oils

Note: Refer to Student Supplement 1 for more information.

Objective 23

Oil maintenance procedures

a. For proper protection, oil must be drained and changed at recommended intervals.

b. Use brands which meet the engine manufacturer's specifications.

c. Select oils that have been performance tested.

d. Never mix oils with different viscosities or API classifications.

e. Use quality oil filters as recommended by the operator's handbook or service manual.

f. Keep oil containers covered, sealed, and protected to prevent contamination.

g. Dispose of oil according to state and federal laws,

Objective 24

Fluids/oils for transmissions and gearboxes

Note: To function properly over many hours and thousands of miles of use, drive train components with gears or similar moving parts must be properly lubricated. Transmissions and other gearboxes are self-contained fluid systems.

a. Manual transmissions

- Functions of manual transmission oil
  - Allows parts to move more easily
  - Cushions the shock between gears and other parts that contact one another
  - Cools metal in the transmission
  - Reduces wear and corrosion
- Lubricants used in manual transmissions
  - Transmission oil
  - Heavy duty engine oil
  - Gear oil (generally heavier than engine oil)
  - Automatic transmission fluid
- Transmission oils serve the same primary purposes as engine oils and, therefore, should share the characteristics of a good engine oil. In fact, many manual transmissions use the same heavy duty oil as engines. Transmission oils should be handled with the same care as engine oils.
- Manual transmission oil maintenance
  - Change transmission oil at recommended intervals.
  - Use only oils of the grade and type specified by the equipment manufacturer.
  - Inspect the transmission regularly for leaks.

b. Automatic transmissions

- Automatic transmissions operate according to hydraulic principles. Consequently automatic transmission fluids (ATFs) must be able to transmit hydraulic power efficiently in addition to performing the functions of manual transmission oils.
- Automatic transmission fluid contains a red dye to distinguish it from other oils.

- Automatic transmissions are engineered to operate with specific types of ATFs, each of which has special properties. Always use exactly the type of ATF specified by the service manual.
- Common types of ATFs are:
  - Dexron I, II, III
  - Type A-A
  - Type C-3
  - Type F
  - Type H
- ATF maintenance
  - Check fluid level regularly with engine idling, transmission in neutral, and oil temperature between 160°F and 200°F.
  - Maintain fluid at correct level. If fluid level is either too low or too high, the transmission will not work properly.
  - Change oil and filter at recommended intervals, following procedures outlined in the service manual.

c. Gearboxes

- Differentials and similar gearboxes require regular maintenance as specified by the owner's manual.
- Always use lubricants that fit the equipment manufacturer's specifications.
- Common types of gear lubricants include:
  - Gear oil—SAE 75-140 and API GL1-6
  - Engine oil
  - Other gear lubricants

Objective 25

Fluids for power steering

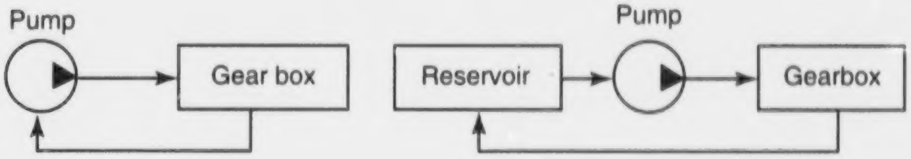
a. Heavy duty equipment may have either air-assisted or hydraulic-assisted power steering.

b. Hydraulic-assisted power steering is a hydraulic system that employs a closed hydraulic circuit.

c. It consists of a pump and a power steering gearbox, which takes the place of the manual steering gearbox in manual steering systems.

d. The hydraulic fluid reservoir might be either a separate component (remote mounted) or it might be within the pump assembly (integral).

Figure 6—Typical hydraulic power steering configurations


Pump
Gear box
Pump
Reservoir
Gearbox

e. Two basic types of fluid may be used in power steering systems.

- Automatic transmission fluid
- Power steering fluid (petroleum-based oil formulated to allow quicker response to pressure changes)

f. Maintenance

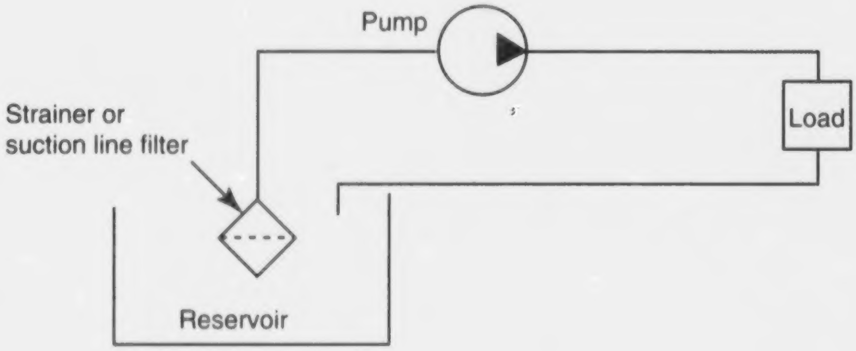
- Check fluid level and inspect system for leaks regularly.
- Always use fluids that meet the manufacturer's specifications.

Objective 26

Locations of filters in hydraulic systems

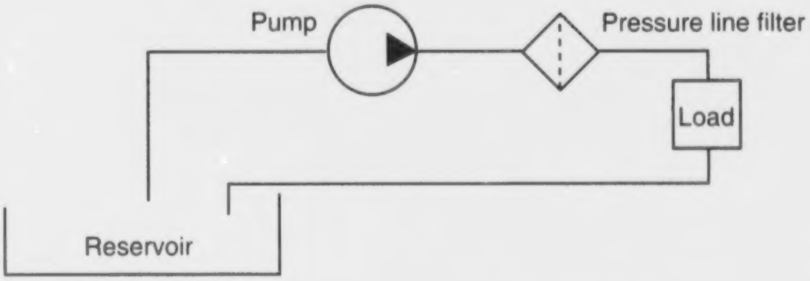
a. Strainer or suction line filter—Pump inlet

Figure 7


Pump
Strainer or suction line filter
Load
Reservoir

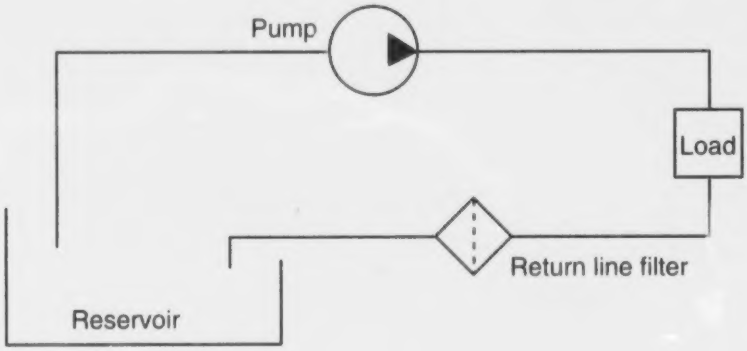
b. Pressure line filter—Pump outlet

Figure 8


Pump
Pressure line filter
Load
Reservoir

c. Return line filter—Return line between pump and reservoir

Figure 9


Pump
Load
Return line filter
Reservoir

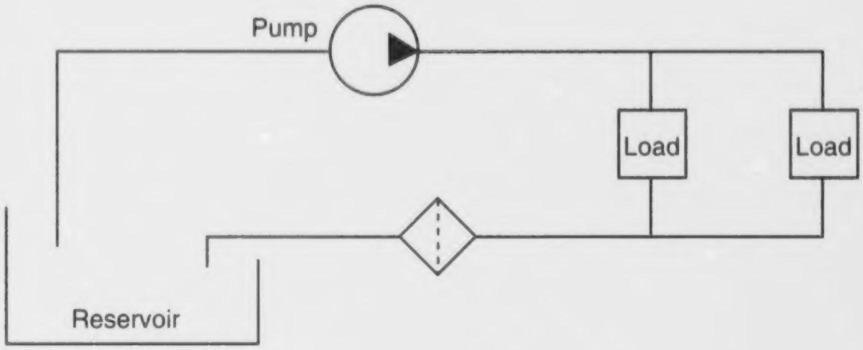
727

Objective 27

Types of filter circuits in hydraulic systems

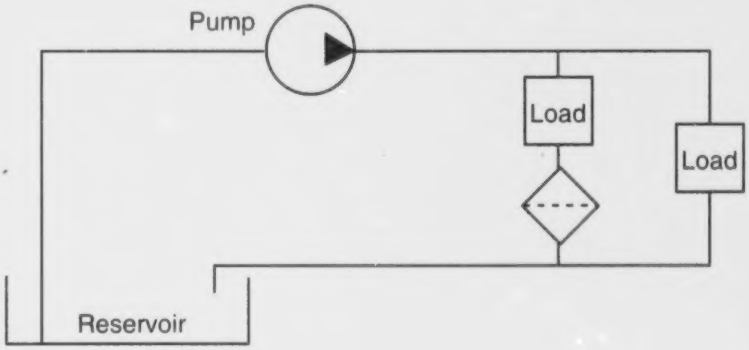
a. Full flow filter

Figure 10


Pump
Load
Load
Reservoir

b. Partial flow filter

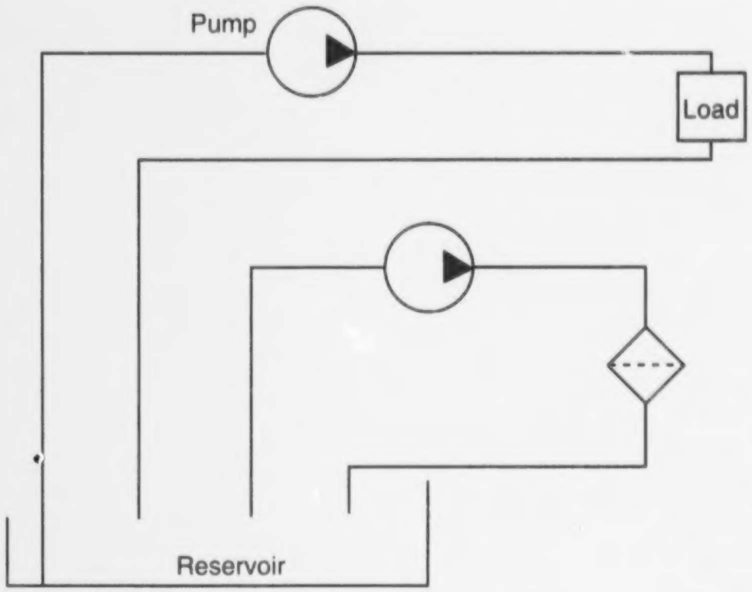
Figure 11


Pump
Load
Load
Reservoir

728

c. Auxiliary flow filter

Figure 12



Objective 28

Chassis lubrication systems

Note: Joints and similar moving points on the chassis and suspension system must be lubricated periodically to ensure proper operation. Modern lubricating systems and fluids minimize chassis maintenance, but regular service is still required.

a. On-board lubrication systems

- Used on modern diesel equipment to eliminate the need to manually grease each individual lubrication point
- Consist of a central distribution manifold and lines that run from the manifold to the individual lubrication points
- Manual on-board lubrication systems have a single fitting on the manifold. A service technician attaches a grease gun to the fitting and pumps grease into the manifold. The grease then flows through the lines to the lubrication points.

b. Automatic chassis lubrication systems (ACLS)

- Add a grease reservoir and an electric motor- or air-driven pump to the basic on-board lubrication system. A timer activates the pump at regular intervals, and a valve system meters the amount of grease delivered at the individual grease points.

- An ACLS wastes less grease than a manual system because the grease can reach the points of contact between parts more readily when the vehicle is in motion.
- An ACLS lubricates the chassis and suspension more effectively than a manual system because it regularly delivers fresh grease to the lubrication points.

Note: Some manual lubrication systems, such as those on semi-trailers, can be coupled to an ACLS to function automatically.

Objective 29

Chassis grease

a. Elements

- Liquid lubricant
- Soap base
- Additives for rust and corrosion resistance, adhesion, and withstanding extreme pressure

b. Characteristics of satisfactory grease

- Stable
- Pumpable
- Water resistant
- Heat resistant

Note: The consistency of grease is stated as NLGI (National Lubricating Grease Institute) ratings ranging from 000 to 6, with lower numbers indicating thinner consistencies and higher numbers thicker. Diesel equipment generally uses greases rated 1, 2, or 3, with 2 most common.

Objective 30

Maintenance of chassis lubrication systems

a. Although on-board lubrication systems minimize chassis and suspension service, some components such as drive shaft U-joints, axles, and wheel bearings still need to be manually lubricated at regular recommended intervals.

b. Use only lubricants that meet the equipment manufacturer's specifications for each individual lubrication point.

c. Always refer to the service manual for make, model, and type of equipment to be certain that all lubrication points are properly greased.

d. Check the level of lubricant in ACLS reservoirs at recommended intervals and fill only with the lubricant recommended by the equipment manufacturer.

e. Inspect the system lines to make sure they are working and correctly routed whenever you service an on-board system.

Objective 31

Batteries

a. The liquid acid solution (electrolyte) in batteries is vital to their generating sufficient electrical power.

b. The electrolyte level in conventional batteries should be just below the bottom of the vent opening. It should never be allowed to drop below the top of the plates.

c. Check batteries regularly and add water when needed.

d. Maintenance-free batteries are sealed and never need additional water.

e. Inspect batteries regularly for corrosion and for breaks, cracks, or other damage.

Student Supplement 1—API Engine Oil Classification

Class S—Gasoline Engine

SB—Minimum-duty gasoline engine service; provides only antiscuff capability, resistance to oil oxidation, and bearing corrosion.

SC—1964 Gasoline engine warranty service; provides control of high- and low-temperature deposits, wear, rust, and corrosion.

SD—1968 Gasoline engine warranty service; gives more protection against high- and low-temperature engine deposits, wear, rust, and corrosion than SC classification.

SE—1972 Gasoline engine warranty service; provides more protection against oil oxidation deposits, high-temperature engine deposits, rust, and corrosion than SD or SC classification oils.

SG (Old classification SF, SE, SF/CC or SE/CC) improves control of engine deposits, oil oxidation, and engine wear. (Gasoline, passenger cars, vans, light-duty trucks beginning in 1989.)

SH (SH/CD and ECII for 5W-30 and 10W-30) (SH and EC for 10W-40)—1995 Gasoline engine service; improved friction modifiers. (Starburst symbol)

Class C—Diesel Engine

CA—Light-duty diesel engine service; provides protection against bearing corrosion and from high-temperature deposits in naturally-aspirated diesel engines.

CB—Moderate-duty diesel engine service; provides necessary protection from bearing corrosion and from high-temperature deposits in naturally-aspirated diesel engines using sulfur fuels.

CC—Moderate-duty diesel and gasoline engine service; provides protection from high-temperature deposits in lightly supercharged diesel engines and also from rust, corrosion, and low-temperature deposits in gasoline engines. (Moderate-to-severe-duty diesel and gasoline trucks, farm tractors, construction and industrial equipment)

CD—Severe-duty diesel engine service 1; provides protection from bearing corrosion and from high-temperature deposits in supercharged engines when utilizing a wide quality range of fuels. (Caterpillar Series 3)

CE—Severe-duty diesel engine service 2; used in turbocharged or supercharged heavy-duty diesel engines.

CF2 (Replaces CDII)—Applies to 2-stroke heavy-duty diesels; tightens requirements on wear and deposits; effective since August 1994.

CG4—Applies to 4-stroke heavy-duty diesels; supports latest low emissions, deposit control, corrosion control, and wear control; effective January 1995.

The API Engine Service Classification Symbol is a registered service mark of the API. It is licensed to engine oil marketers for use on containers of the certified oils which meet or exceed the technical requirements defined by ASTM. The information above was provided courtesy of American Petroleum Institute, 1220 L Street, NW, Washington, D.C. 20005. Phone 202-682-8000 for more information.

Objective 32

Job Sheet 1—Test for Combustion Leakage into a Cooling System

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Followed safety rules throughout	______
• Drained system and prepared for test properly	______
• Performed test properly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Shop towels
- Basic hand towels
- Appropriate service manual
- Live engine

Note: The procedure below is generic and may differ from engine manufacturers' procedures. Always use manufacturers' procedures when possible.

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Operate the engine until it reaches operating temperature.

☐ 2. Drain enough coolant to allow removal of the upper hose and thermostat.

☐ 3. Remove the thermostat, upper radiator hose, and drive belts.

☐ 4. Refill system with coolant until it reaches the level of the thermostat-housing neck.

☐ 5. Start engine and accelerate five to six times.

☐ 6. Watch the outlet opening for bubbles or a rise of liquid.

Note: Appearance of bubbles or a rise of liquid indicates that combustion gases are entering the cooling system.

Caution: Perform the test as quickly as possible; otherwise the coolant will boil and steam, and bubbles will rise from the thermostat neck causing misleading test results.

☐ 7. Describe the results of your test below. What did you see? What does this indicate?

____

____

____

☐ 8. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 33

Job Sheet 2—Test for Air in a Cooling System

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Drained system and prepared for test properly	______
• Performed test properly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Shop towels
- Basic hand tools
- Appropriate service manual
- Live engine
- Transparent plastic tube

Note: The procedure below is generic and may differ from engine manufacturers' procedures. Always use manufacturers' procedures when possible.

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Drain enough coolant from the system to remove top radiator hose from thermostat housing and radiator top tank.

☐ 2. Place a transparent plastic tube between the thermostat housing and radiator top tank.

☐ 3. Refill the system and start the engine.

☐ 4. Run engine until it reaches normal operating temperature.

☐ 5. Observe the coolant flow.

☐ 6. Check for white round particles passing out of the cylinder head into the radiator through the plastic hose.

☐ 7. Describe the results of your test below. What did you see? What does this indicate?

____

____

____

☐ 8. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ____

____

____

737

Objective 34

Job Sheet 3—Clean a Cooling System

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Allowed system to cool to proper temperature	______
• Drained and flushed system properly	______
• Installed new coolant filter correctly	______
• Installed correct coolant solution and checked system properly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Basic hand tools
- Sodium carbonate and water
- Drain pan
- Shop towels
- Live engine
- Appropriate service manual
- New coolant filter
- Antifreeze and water

Note: The procedure below is generic and may differ from engine manufacturers' procedures. Always use manufacturers' procedures when possible.

Caution: Follow all shop safety procedures.

Procedure

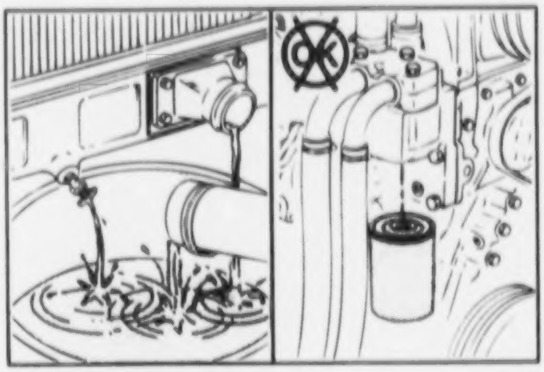
☐ 1. Remove the radiator cap after the engine has cooled.

Caution: Wait until the coolant temperature is below 160°F before removing the radiator cap.

☐ 2. Open the radiator draincock and remove the lower radiator hose and drain cooling system.

Note: Do not remove the coolant filters.

Figure 1



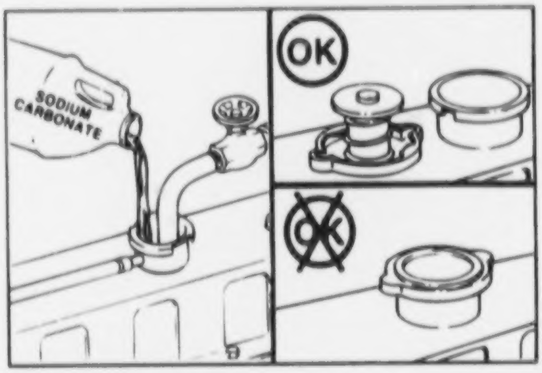
Courtesy of Cummins Engine Company, Inc.

☐ 3. Install bottom radiator hose and close draincock.

☐ 4. Fill the system with a mixture of sodium carbonate and water, or a commercially available equivalent.

Note: Use 1.0 percent of sodium carbonate for every 6 gallons of water.

Figure 2

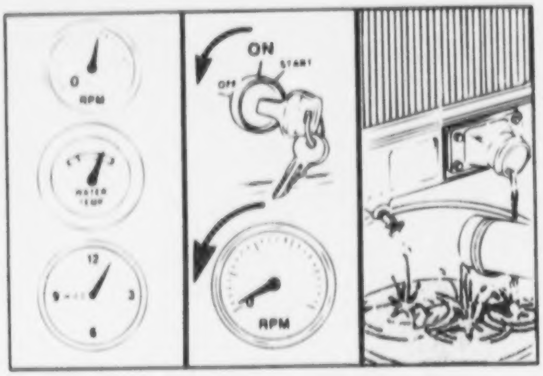


Courtesy of Cummins Engine Company, Inc.

Caution: Do not install the radiator cap or new coolant filters.

☐ 5. Operate the engine for 5 minutes with the coolant temperature above 180° F.

Figure 3



Courtesy of Cummins Engine Company, Inc.

☐ 6. Shut off the engine and drain the cooling system.

☐ 7. Fill the cooling system with clean water.

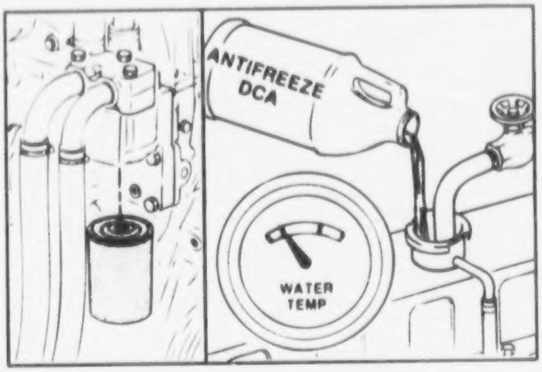
☐ 8. Operate the engine for 5 minutes with the coolant temperature above 180° F.

☐ 9. Shut off the engine and drain the cooling system.

Note: If the water being drained is still dirty, the system must be flushed again until the water is clean.

☐ 10. Install a new coolant filter, and fill the cooling system with a mixture of 50% antifreeze and 50% water.

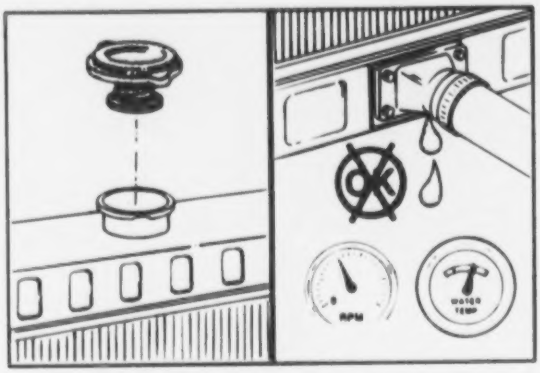
Figure 4



Courtesy of Cummins Engine Company, Inc.

☐ 11. Install the pressure cap and operate the engine; check for coolant leaks.

Figure 5



Courtesy of Cummins Engine Company, Inc.

☐ 12. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 35

Job Sheet 4—Change Oil and Filter

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Removed replaceable element-type oil filter and cleaned housing correctly	______
• Installed new filter and refilled crankcase correctly	______
• Checked system and oil level correctly	______
• Removed sealed cartridge-type oil filter and cleaned housing correctly	______
• Installed new filter and refilled crankcase correctly	______
• Checked system and oil level correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Engine
- Appropriate service manual
- Shop towels
- Drain pan
- Suitable wrenches to remove oil filter
- Safety glasses
- New oil filters, element-type and/or cartridge-type
- New oil
- New oil filter housing gasket
- Service sticker

Note: The procedure below is generic and may differ from engine manufacturers' procedures. Always use manufacturers' procedures when possible.

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Run engine until it reaches operating temperature.

☐ 2. Change replaceable, element-type oil filter. (Proceed to step 3 for cartridge-type filter.)

☐ a. Position drain pan under oil filter.

☐ b. Remove filter housing drain plug and allow oil to drain.

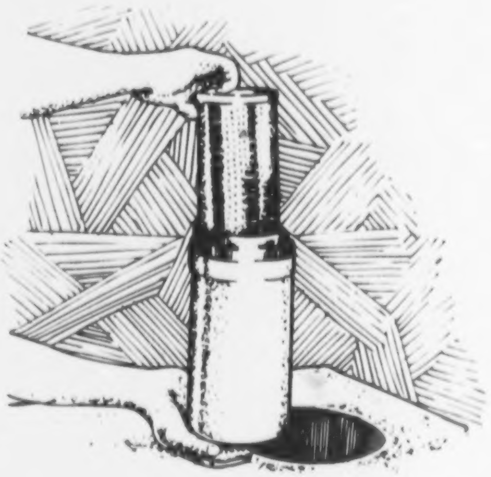
> Caution: Be careful with hot oil which can seriously burn the skin.

☐ c. Remove oil filter housing bolt.

☐ d. Remove oil filter housing.

☐ e. Remove oil filter element from filter housing.

Figure 1



☐ f. Clean the filter housing.

☐ g. Remove old oil filter housing gasket.

☐ h. Install new oil filter housing gasket making sure the new gasket is placed correctly.

☐ i. Install new oil filter element in housing filter.

☐ j. Install oil filter housing and tighten bolt securely.

☐ k. Add oil or refill crankcase as required.

☐ l. Start engine.

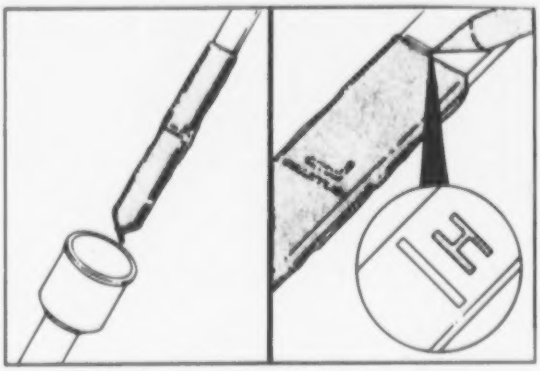
☐ m. Check for leaks.

☐ n Shut off engine

☐ o. Check oil level on dipstick.

Note: When changing oil, refill to correct capacity and check dipstick for accuracy.

Figure 2



Courtesy of Cummins Engine Company, Inc.

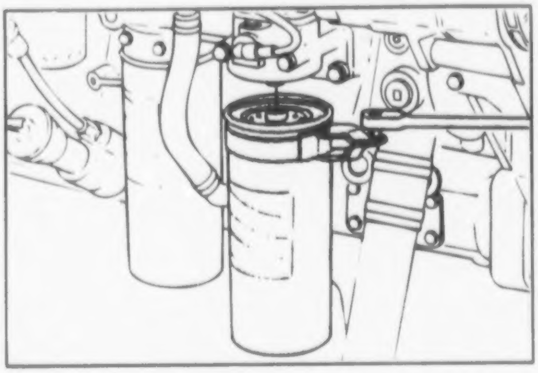
☐ p. Write service sticker indicating date and mileage oil filter was changed.

☐ 3. Change sealed, cartridge-type oil filter.

☐ a. Place drain pan under oil filter.

☐ b. Remove oil filter cartridge with suitable tool, turning counterclockwise to remove, and allow oil to drain.

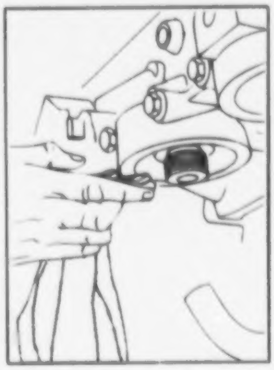
Figure 3



Courtesy of Cummins Engine Company, Inc.

☐ c. Clean the oil filter head surface.

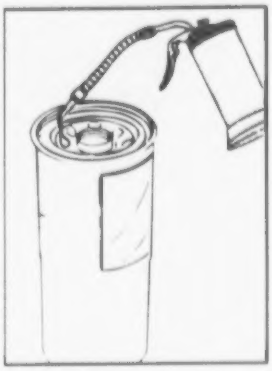
Figure 4



Courtesy of Cummins Engine Company, Inc.

☐ d. Lubricate the sealing gasket on the new oil filter cartridge with clean motor oil.

Figure 5



Courtesy of Cummins Engine Company, Inc.

☐ e. Fill the filters with clean motor oil.

☐ f. Install the filters on the oil filter head and tighten the filters until the gasket contacts the filter head surface.

☐ g. Use an oil filter wrench to tighten the filters an additional three-fourths to one turn, or follow the instructions supplied with the filters.

☐ h. Start engine.

745

- ☐ i. Check for leaks.
- ☐ j. Shut off engine.
- ☐ k. Check oil level on dipstick.
- ☐ l. Write service sticker indicating date and mileage oil filter was changed.

☐ 4. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Unit Contents

Student Components

Student Page

Objective Sheet . . . 1C-3

Information Sheet . . . 1C-5

Assignment Sheets

1—Solve Problems Using Ohm's Law . . . 1C-31
2—Interpret Electrical Values From Multimeter Settings . . . 1C-33
3—Interpret Wiring Diagrams . . . 1C-39

Job Sheets

1—Measure Current, Voltage, and Resistance with a Multimeter . . 1C-43
2—Test and Replace Light Bulbs and Test Sockets . . . 1C-49
3—Tin a Soldering Iron or Gun . . . 1C-55
4—Solder-Splice Electrical Wiring . . . 1C-57
5—Install Terminals and Connectors . . . 1C-61
6—Test Charge a Conventional (Non-Sealed) Battery . . . 1C-67
7—Test Charge a Sealed Battery . . . 1C-71
8—Slow Charge a Battery . . . 1C-73
9—Perform a Battery Load Test . . . 1C-79
10—Perform a High-Rate Battery Charge Test . . . 1C-85
11—Emergency Jump-Start a Vehicle . . . 1C-91

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss basic electrical principles and perform basic maintenance on electrical systems. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic electrical principles with their correct definitions.
2. Distinguish between true and false statements regarding the electron theory of electricity.
3. Match characteristics of electricity with their correct descriptions.
4. Match basic electrical units with their measurements.
5. Express Ohm's law and Watt's law.
6. Match equipment used to measure electrical characteristics with their correct descriptions.
7. Match components of a basic electrical circuit with their purposes.
8. Distinguish between types of electrical current flow.
9. Identify types of basic electrical circuits.
10. Describe electron flow through a single wire circuit.
11. Match circuit protection devices with their correct descriptions.
12. Distinguish among types of electrical circuit problems.
13. Identify schematic symbols used on wiring diagrams.
14. Complete statements on how to read wiring diagrams.
15. Arrange in order the steps in soldering.
16. Complete statements concerning guidelines for soldering.
17. Complete statements concerning electrical terminals and connectors.
18. Identify battery service tools.
19. Complete statements concerning guidelines for servicing batteries.

Objective Sheet

20. Distinguish between correct and incorrect safety procedures to follow when working on batteries.
21. Solve problems using Ohm's law. (Assignment Sheet 1)
22. Interpret electrical values from multimeter settings. (Assignment Sheet 2)
23. Interpret wiring diagrams. (Assignment Sheet 3)
24. Measure current, voltage, and resistance with a multimeter. (Job Sheet 1)
25. Test and replace light bulbs and test sockets. (Job Sheet 2)
26. Tin a soldering iron or gun. (Job Sheet 3)
27. Solder-splice electrical wiring. (Job Sheet 4)
28. Install terminals and connectors. (Job Sheet 5)
29. Test charge a conventional (non-sealed) battery. (Job Sheet 6)
30. Test charge a sealed battery. (Job Sheet 7)
31. Slow charge a battery. (Job Sheet 8)
32. Perform a battery load test. (Job Sheet 9)
33. Perform a high-rate battery charge test. (Job Sheet 10)
34. Emergency jump-start a vehicle. (Job Sheet 11)

Information Sheet

Objective 1

Terms and definitions

a. **Ampere**—Quantity of current flowing through a conductor or circuit (usually expressed in amps)

b. **Analog volt-ohmmeter (VOM)**—Meter that uses a needle pointer and scale to display volts, amps, or ohms

c. **Circuit**—Continuous path along a conductor through which electrical current can flow from an energy source through a load and back to the source

d. **Current**—Flow of electrons through a conductor

e. **Conductor**—Material through which electricity flows easily

Examples: Most metals, especially copper and steel

f. **Digital volt-ohmmeter (DVOM)**—Meter that uses a digital number readout to display volts, amps, or ohms

g. **Electrode**—Conductor such as a battery terminal that connects electrolyte to a metallic conductor

h. **Electrolyte**—Nonmetallic conductor (such as battery acid and water) that carries current between positive and negative points

i. **Fuse**—Electrical safety device with a wire or easily melted metal strip

Note: If the current flow through the fuse becomes too great, the wire or strip will melt, thus opening up the circuit.

j. **Insulator**—Material that resists the flow of electricity

Examples: Rubber, wood, plastic

k. **Load**—Portion of an electric circuit where electricity is converted to another form of energy

Examples: The light filament in a headlight (electricity to light), the heating element of an electric heater (electricity to heat), the armature of a starting motor (electricity to mechanical power)

l. **Open (circuit)**—Break or incomplete path in the circuit that does not allow current to flow

m. **Oscilloscope**—Electronic meter that displays a voltage signal over a unit of time on a TV-like display screen or liquid crystal display (LCD) screen

n. **Resistance**—Electrical property of a conductor or device that opposes the flow of current (measured in ohms)

Note: Current that flows through resistance generates heat.

o. **Semiconductor**—Material that under certain operating conditions acts like a conductor; under other conditions it will act like an insulator

Note: A diode is a semiconductor device.

p. **Short circuit (short)**—Accidental low resistance connection between two points that results in an alternate current path that either deflects current from the desired paths or will cause excessive current that can result in damage to circuit components

Note: It is possible to have a short to power or a short to ground.

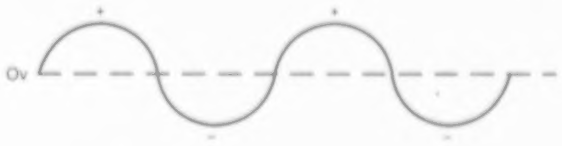
q. **Voltage**—Electrical pressure used to move electrons through a conductor

Note: Voltage is also known as electromotive force.

r. **Waveform**—Graphic representation of the shape of a wave as it oscillates between positive voltage peak and negative voltage peak

Example:

Figure 1



s. **Wiring diagram (schematic)**—Drawing that uses electrical symbols to show electrical circuits

Objective 2

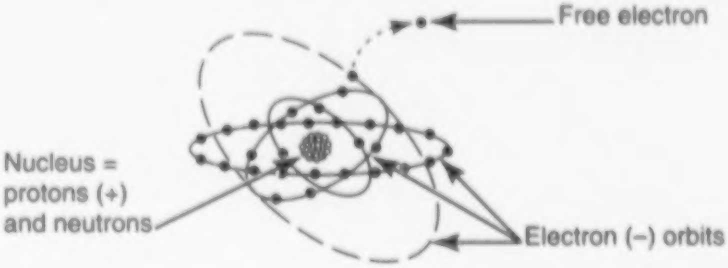
Electron theory of electricity

Note: The electron theory of electricity explains how scientists think electricity works. It is based on the principles listed below.

a. Everything is made up of atoms.

b. Atoms are made up of three types of particles: protons, neutrons, and electrons.

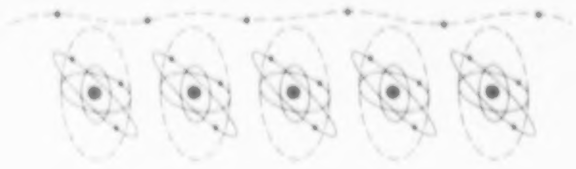
Figure 2



- Protons, which carry a positive charge (+), and neutrons, which carry no charge, make up the middle of the atom, called the *nucleus*.
- Electrons, which carry a negative charge (–), revolve around the nucleus in paths called *orbits*. Electrons in the outer unfilled orbit are called *free electrons*.

c. In some substances, called *conductors*, free electrons will move (flow) from one atom to another when energy is applied. This flow of electrons is called *electricity*.

Figure 3



d. The electron theory of electricity states that electrons flow from negative to positive.

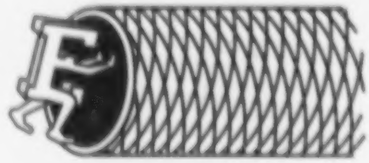
Information Sheet

Objective 3

Characteristics of electricity

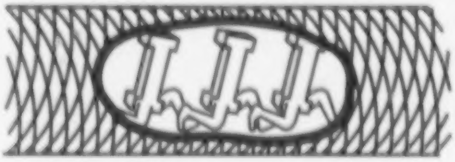
a. **Electromotive force (emf) (E)**—The amount of energy in a current measured as the pressure that pushes electron flow

Figure 4



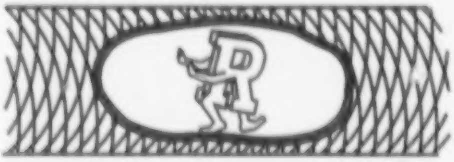
b. **Current intensity (I)**—The number of electrons flowing past a given point in a second

Figure 5



c. **Resistance (R)**—The amount of a substance's opposition to electrical flow

Figure 6



Objective 4

Basic electrical units and their measurements

a. **Volt (V)**—Measures electromotive force (E)

b. **Ampere (Amp)**—Measures the intensity (I) of an electrical current

Note: One ampere, or "amp," equals 6,250,000,000,000,000 electrons moving past a point in one second.

c. **Ohm (Ω)**—Measures resistance (R)

d. **Watt**—Measures electrical power (P)

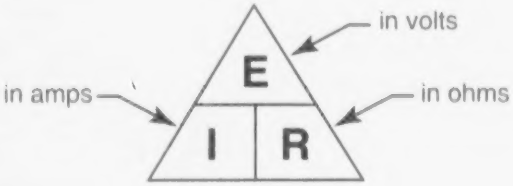
Objective 5

Relationships of electrical properties expressed by Ohm's law and Watt's law

a. **Ohm's law**

- States that the electromotive force (voltage) in a circuit is equal to the amount of current (intensity or amperage) multiplied by the amount of resistance (ohms) in the conductor
- The usual mathematical expression of Ohm's law is $E = I \times R$ (Force = Current x Resistance)
- Ohm's law is often shown as a triangle which shows the different ways of expressing the same relationship in equations.

Figure 7

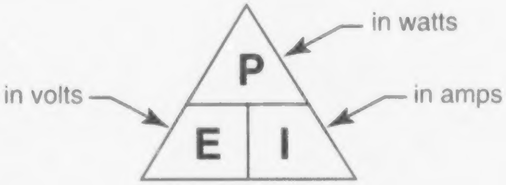


$E = I \times R$
$I = E/R$
$R = E/I$

b. **Watt's law**

- States that the power (watts) in a circuit is equal to the electromotive force (volts) multiplied by the intensity (amps) of the current
- The usual mathematical expression is $P = E \times I$ (Power = Force x Intensity)
- Watt's law, too, can be shown as a triangle which shows the different ways of expressing the same relationship in equations.

Figure 8



$P = E \times I$
$I = P/E$
$E = P/I$

Objective 6

Equipment used to measure electrical characteristics

a. **Voltmeter**—Measures electromotive force (volts)

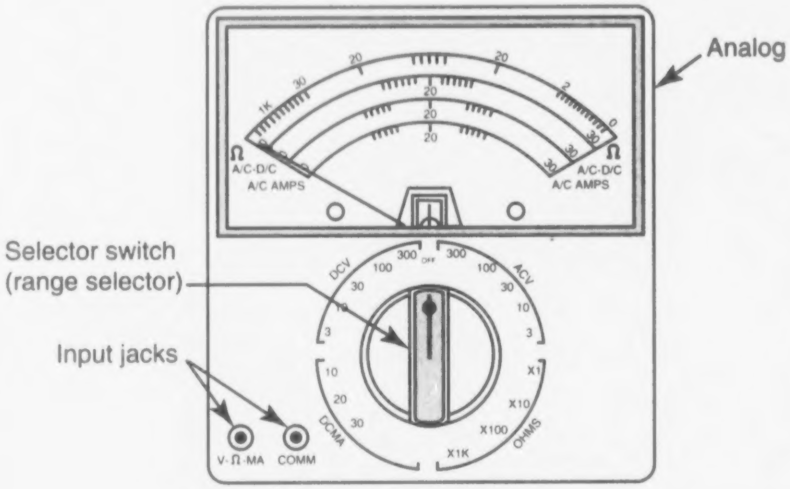
b. **Ammeter**—Measures current intensity (amperes or amps)

c. **Ohmmeter**—Measures resistance (ohms)

d. **Multimeter**—Measures electromotive force, current intensity, and resistance (volts, amps, and ohms); may be analog or digital

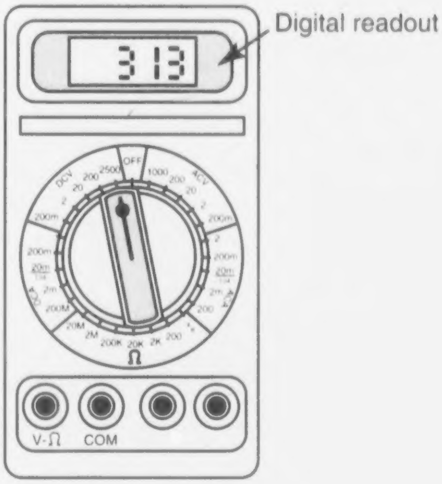
- Analog volt-ohmmeter (VOM)—Uses current to move a needle that indicates the level of the selected electrical characteristics

Figure 9


Analog
Selector switch (range selector)
Input jacks
Ω
A/C-D/C
A/C AMPS
DCV
ACV
OFF
DCMA
OHMS
X1
X10
X100
X1K
V·Ω·MA
COMM

- Digital volt-ohmmeter (DVOM)—Uses electronic circuitry to measure the selected electrical property and displays a numeric reading

Figure 10



e. **Test light**—Indicates the presence of current without measuring any of its characteristics

f. **Self-powered test light**—Indicates a closed circuit condition

Objective 7

Components of a basic electrical circuit and their purposes

a. **Energy source**—Produces the energy that causes electrons to flow; the two most common types of energy sources for diesel equipment are:

- Chemical energy produced by batteries
- Mechanical energy produced by alternators, generators, and magnetic coils

b. **Conductor**—Provides a path for the electricity to flow from the power source and through the circuit; usually copper wire in diesel equipment

c. **Load**—Converts electricity into another form of energy

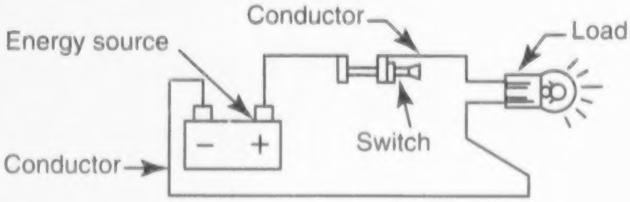
Examples: Lights, horn, starter motor

d. **Switch**—Opens or closes the circuit

- Open switch—Breaks the circuit, interrupting the flow of electricity and turning off the load

- Closed switch—Completes the circuit, allowing the flow of energy and turning on the load

Figure 11—Basic electrical circuit components



Objective 8

Types of electrical current flow

a. **Direct current** (DC)

- Electricity flows in one direction only.
- The energy source is generally a battery or DC generator.

b. **Alternating current** (AC)

- Electricity flows in one direction and then reverses direction on a regular basis.
- The energy source is generally an AC alternator or commercial power source.

Objective 9

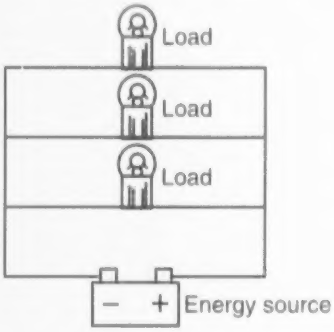
Types of basic electrical circuits

a. **Parallel circuit**

Examples: All load circuits are in parallel with battery terminals.

- The circuit provides more than one path for electricity to flow from the energy source to the load(s) and back to the energy source.
- If an open condition occurs in any one path, current stops flowing to the load on that path but continues to flow along the other paths.

Figure 12—Parallel circuit



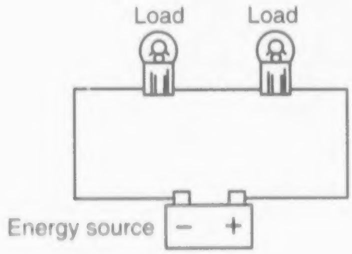
757

b. **Series circuit**

Examples: AC compressor clutch control circuit, blower speed control circuit

- The circuit provides only one path from the energy source through the load and back to the energy source.
- If an open condition occurs anywhere in the circuit, the current stops flowing.

Figure 13—Series circuit

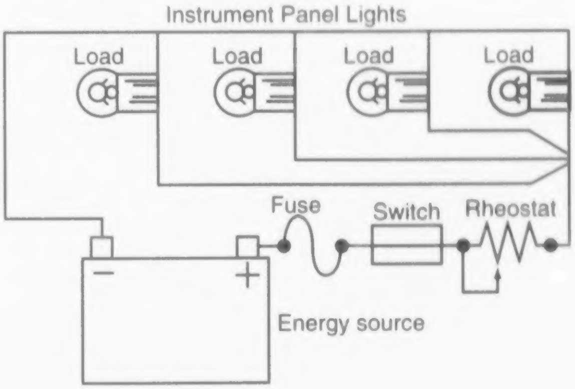

Load
Load
Energy source
–
+

c. **Series-parallel circuit**

Examples: Headlights, taillights, instrument panel lights

- Circuit usually has a switch connected in series; switch controls electricity flow to loads connected in parallel paths of the circuit.
- Should an open occur in the series portion of the circuit, current stops flowing in the entire circuit; should an open occur in any one of the paths in the parallel circuit, current stops flow through that path but continues flowing through the other paths.

Figure 14—Series-parallel circuit


Instrument Panel Lights
Load
Load
Load
Load
Fuse
Switch
Rheostat
–
+
Energy source

Objective 10

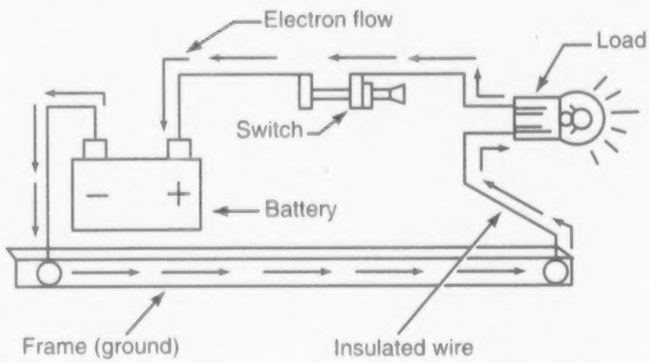
Electron flow through a single wire circuit

Note: In equipment with a metal frame, the frame can replace one of the wires in a two-wire circuit.

a. **Negative ground** (most common)

- The negative terminal of the battery is connected to the equipment frame or chassis (ground).
- One side of the load is also connected to the frame or chassis (ground) for the return path.
- The positive terminal of the battery is connected to the load with insulated wire and a control device, completing the path for current flow.

Figure 15

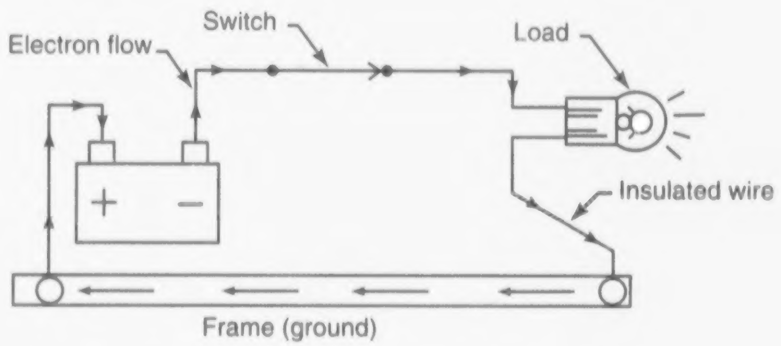


b. **Positive ground**

- The positive terminal of the battery is connected to the equipment frame or chassis (ground).
- One side of the load is also connected to the frame or chassis for the return path.
- The negative terminal of the battery is connected to the load with insulated wires and a control device, completing the path for current flow.

759

Figure 16


Electron flow
Switch
Load
Insulated wire
+
−
Frame (ground)

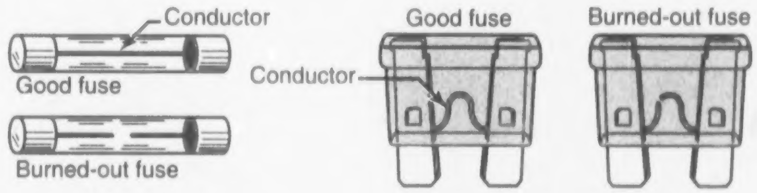
Objective 11

Circuit protection devices

a. **Fuses**

- Are devices that contain a soft metal conductor that melts when excessive current flows through it, permanently opening the circuit until the fuse is replaced.
- When replacing a melted/burnt fuse, select and install a fuse with same rating or color as the melted fuse.

Figure 17

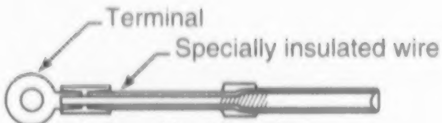

Conductor
Good fuse
Burned-out fuse
Good fuse
Burned-out fuse
Conductor

(a) Tube-type glass fuse **(b) Miniaturized translucent fuse**

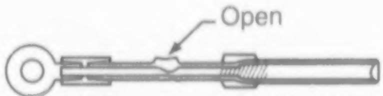
b. **Fusible links**

- Are specially insulated wires that melt when excessive current flows through them, permanently opening the circuit until replaced or repaired.
- Be sure to match the replacement fusible link to the original link for continued protection.

Figure 18



(a) Good fusible link

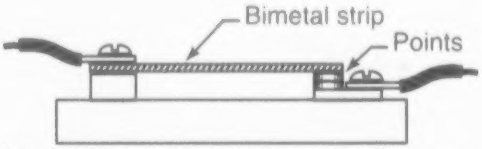


(b) Burned-out fusible link

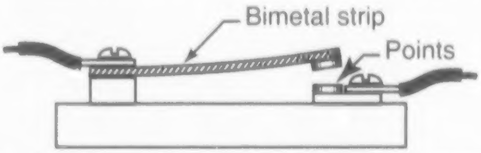
c. **Circuit breaker**

- Contains a bimetal strip that bends away from contact points when excessive current flows through the circuit; when the bimetal strip cools, it straightens, and the points make contact again
- Match the replacement breaker to the original breaker for continued protection.
- Do not use a circuit breaker to protect electronic equipment. The response time of the breaker is not fast enough to prevent surge current damage to the components.

Figure 19



(a) Circuit breaker carries normal current; bimetal strip contacts points. Circuit is closed.



(b) Circuit breaker carries excessive current; bimetal strip bends away from points. Circuit is open.

Objective 12

Types of electrical circuit problems

a. **Open**—Condition in which a break in the circuit prevents current flow

- Planned—Not all opens are problems; some open circuits are planned in order to operate the load or to avoid dangerously overloading the circuit.
    - A switch in the off position is a planned circuit opening.
    - Circuit protectors create planned openings when too much heat or current is in a circuit.
- Accidental—Unintended openings are a primary cause of problems in electrical systems. Common causes of accidental circuit openings are:
    - Broken or loose wiring
    - Faulty switches
    - Faulty loads

b. **Short**—Condition in which current flows out of the intended circuit

- Short-to-ground—Electricity flows from the circuit into another conductor, usually as a result of a conductor penetrating wire insulation or an exposed switch or load surface. (Stop switches cause deliberate shorts-to-ground.)
- Wire-to-wire short—Wires from different circuits touch along conductive surfaces, usually as a result of two wires rubbing against each other until their insulation is worn away or cracks due to wear or age.

c. **High resistance**—Condition in which circuit conductivity is reduced to the point that current flow is not sufficient to operate loads

- The resistance to current flow in a connector between an energy source and a load reduces the amount of energy that reaches the load.
- Factors affecting resistance
    - Conductivity of the substance of which the connector is made
    - Length of the circuit
    - Diameter ("gauge") of the conductor

    Note: The diameter of a wire is stated as its gauge—the higher the gauge number, the smaller the diameter of the wire and the greater its resistance.

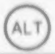
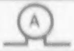
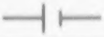
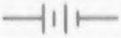
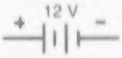
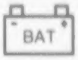
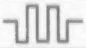
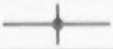
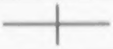
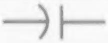
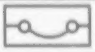
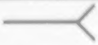
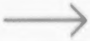
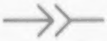
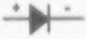
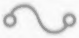
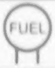
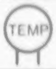
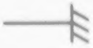
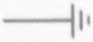
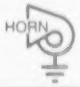
- Temperature
- Presence of nonconductive impurities such as corrosion around a battery terminal

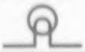
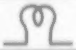
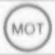
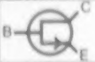
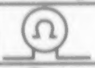
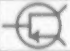
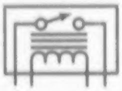
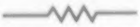
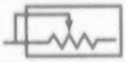
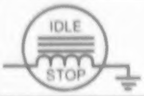
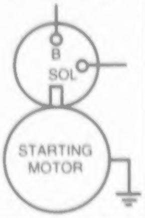
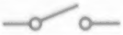
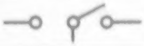
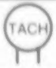
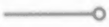
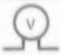
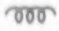
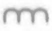
Objective 13

Schematic symbols used on wiring diagrams

Note: Wiring diagrams, or schematics, are illustrations that identify the components of a circuit and provide other information such as current requirements of loads and resistance values of components. Wiring diagrams use schematic symbols to represent components. Schematic symbols bear little or no physical resemblance to the components they represent. See Table 1.

Table 1—ELECTRICAL SYMBOLS

REPRESENTS	SYMBOL
Alternator	
Ammeter	
Battery – One Cell	
Battery – Multicell	
The Long Line is Always Positive Polarity	
Battery – Voltage Box	
Bimetal Strip	
Cable Crossing – Connected (Splice)	
Cable Crossing – Not Connected	
Capacitor	
Circuit Breaker	
Connector – Female Contact	
Connector – Male Contact	
Connectors – Separable – Engaged	
Diode	
Fuse	
Gauge – Fuel	
Gauge – Temperature	
Ground – Chasis Frame (Preferred)	
Ground – Chasis Frame (Acceptable)	
Horn	

REPRESENTS	SYMBOL
Lamp or Bulb (Preferred)	
Lamp or Bulb (Acceptable)	
Motor – Electric	
Negative	—
NPN Transistor	
Ohmmeter	
PNP Transistor	
Positive	+
Relay	
Resistor	
Resistor – Variable	
Solenoid – Idle Stop	
Starting Motor	
Switch – Single Pole, Single Throw	
Switch – Single Pole, Double Throw	
Tachometer	
Termination	
Voltmeter	
Winding – Inductor	 OR 

Objective 14

How to read wiring diagrams (schematics)

a. When tracing power flow through a wiring diagram, one would normally start at the voltage and current source (commonly the battery as in Figure 20), and follow the path of the connecting wire through each diagram component.

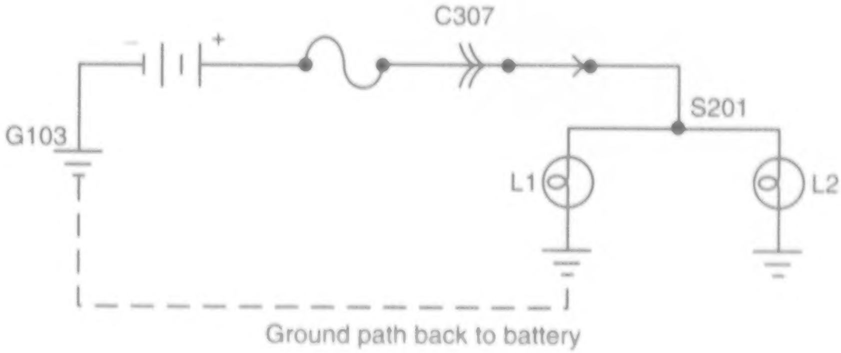
b. Connectors that attach to circuit components may be labeled with the letter "C" and a number for future reference.

c. Splice junctions are usually labeled with an "S" and a number.

d. Grounds are usually labeled with the letter "G" and a number.

e. In many diagrams, there is no return wire as the chassis or frame provides that path.

Figure 20



f. Some diagrams are read left to right but most wiring diagrams today are read top to bottom. The top of the diagram is the positive of the circuit (connection to fuses, fusible links, or circuit breakers) and the bottom part is the ground (return) path back to the battery.

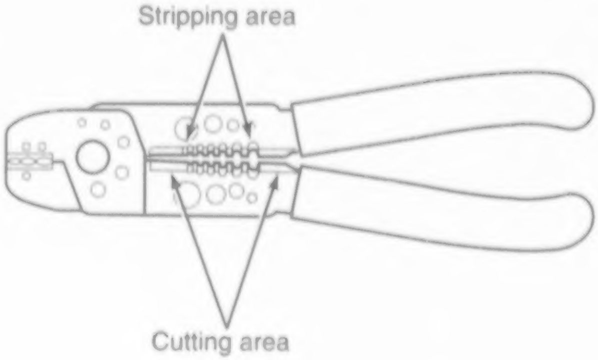
Objective 15

Steps in soldering

Note: Electrical circuits can often be repaired by splicing and soldering electrical wires.

a. Strip wire (remove its insulation) using an electrician's stripper-crimper. Use the proper hole for the gauge of wire you are stripping to prevent nicks and cuts.

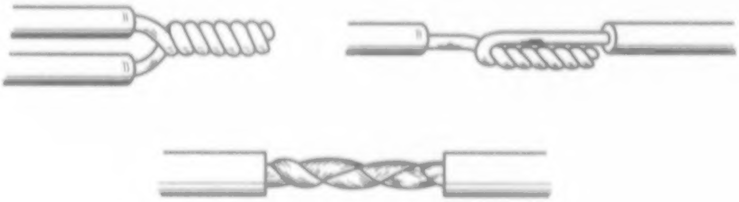
Figure 21


Stripping area
Cutting area

b. Clean the exposed wiring using rosin-type cleaning-flux solution (not acid flux!) to ensure a good electrical connection.

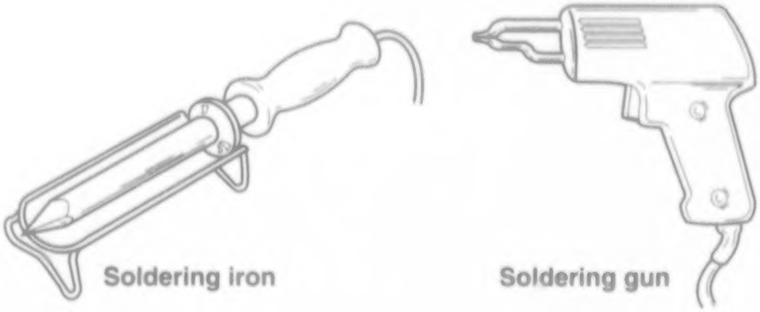
c. Twist or splice the exposed wiring securely, but gently.

Figure 22



d. Put on safety glasses and then prepare soldering iron or soldering gun by cleaning and tinning the tip with a thin coat of rosin-core solder.

Figure 23


Soldering iron
Soldering gun

e. Solder exposed pieces of spliced wiring using soldering iron or gun and rosin-core solder. Acid-base solder should not be used in electrical circuits.

f. Allow solder to cool and then test connection to make sure it is secure.

g. Reinsulate the connection using electrical tape or heat-shrink insulation and a heat gun.

Objective 16

Guidelines for soldering

a. Always wear protection while soldering. Hot solder can cause serious eye injury.

b. Hold the tip of the soldering iron or gun so that a large area of the tip contacts the wiring until the wiring gets hot enough to melt the solder. Enough heat must be generated so that the solder flows freely as a liquid and does not become pasty or mushy.

c. Move the solder along the wiring to allow the solder to cover the length of the splice.

d. Use only enough solder to flow between the wiring strands to form a good bond. Do not build up solder on the surface of the wiring.

e. A well-soldered connection (joint) will appear smooth and shiny, with no apparent holes. A poorly soldered connection—a connection soldered with heat insufficient to properly heat the wire, called a cold joint—will have a dull, rough appearance.

f. Soldered connections must meet two requirements:

- Good physical connection
- Good electrical connection

Objective 17

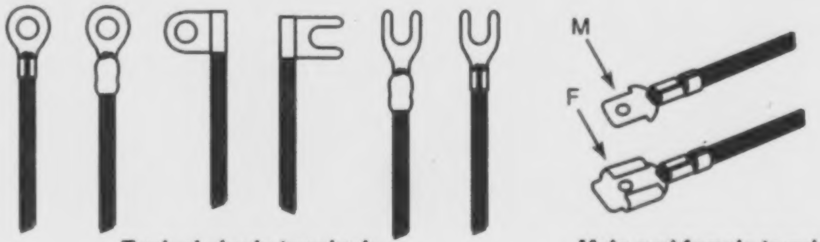
Electrical terminals and connectors

a. A **terminal** is a small conductive metal device that is attached to the end of a wire so that the wire may be easily connected and disconnected to other wires or electrical-circuit components.

b. Some terminals are designed to be used singly and some are designed to be used in attaching pairs. In terminal pairs, one terminal is called a **female terminal** and the other is called a **male terminal**.

767

Figure 24



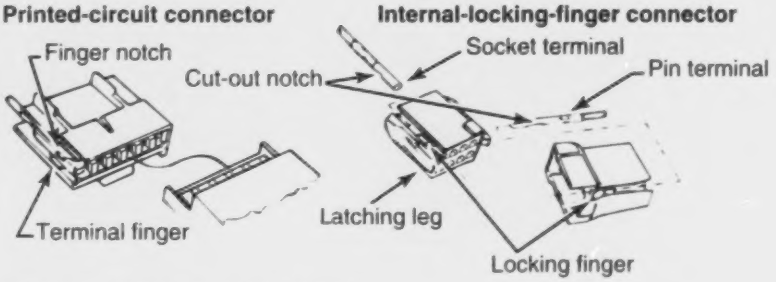
Typical single terminals **Male and female terminals**

c. A **connector** is a nonconductive plastic device that holds two or more terminals in position.

d. Connectors provide a way of disconnecting components or a portion of a circuit from the main wiring harness.

e. Connectors are also designed in attaching pairs, with one connector holding male terminals and the other holding female terminals, or with each having a mixture of male and female terminals.

Figure 25

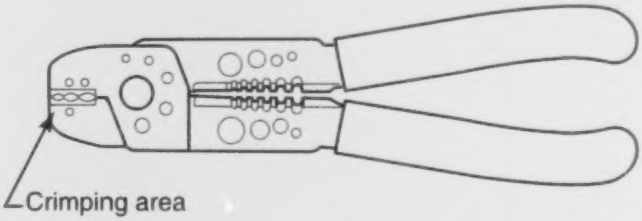

Printed-circuit connector
Finger notch
Terminal finger
Internal-locking-finger connector
Socket terminal
Pin terminal
Cut-out notch
Latching leg
Locking finger

Used with permission of Ford Motor Company.

f. Terminals and connectors to be used in locations exposed to moisture or in circuits carrying large amounts of current must be soldered in place.

g. For most other applications, terminals and connectors can merely be crimped to wires with the crimping area of a wire stripper-crimper.

Figure 26



h. Crimped connections are called **solderless** using special solderless terminals and connectors.

i. Solderless terminals and connectors are color-coded to ensure that you select the proper terminal or connector for the conductor to which it will be attached.

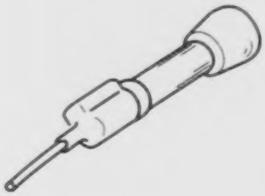
- Solderless terminals and connectors with **red** ends are to be used with 18-gauge and smaller conductors.
- Those with **blue** ends are to be used with 14- and 16-gauge conductors.
- Those with **yellow** ends are to be used with 10- and 12-gauge conductors.

Objective 18

Battery service tools

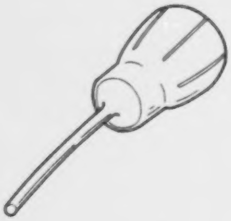
a. Battery hydrometer—Used to measure electrolyte's specific gravity (state of charge)

Figure 27



b. Battery syringe—Used to fill battery cells

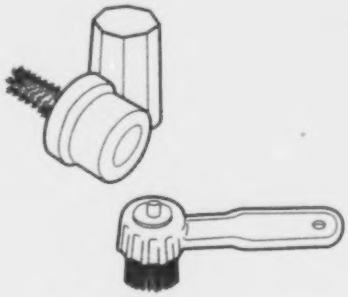
Figure 28



769

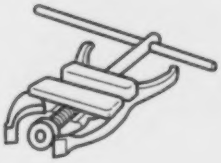
c. Battery post cleaner

Figure 29



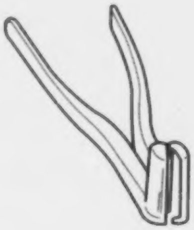
d. Battery terminal clamp puller

Figure 30



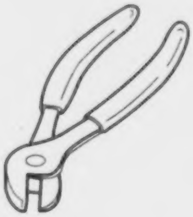
e. Terminal spreader plier

Figure 31



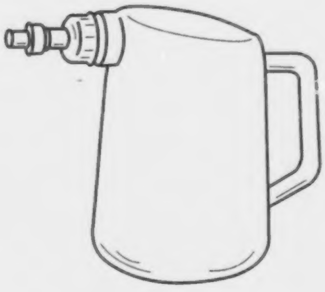
f. Angle nose (battery bolt) plier

Figure 32



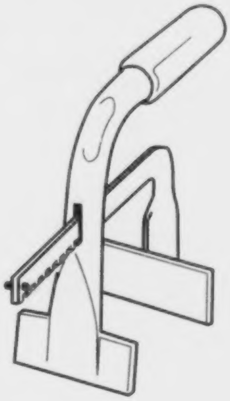
g. Automatic battery filler

Figure 33



h. Battery carrrier

Figure 34



Objective 19

Guidelines for servicing batteries

a. The charge on conventional batteries can be determined by checking the electrolyte weight or specific gravity. This is done with a hydrometer.

- When the weight of the electrolyte is low, the battery's state of charge is low.
- When the weight of the electrolyte is high, the battery's state of charge is high.

b. A change in temperature will change the specific gravity of electrolyte, which in turn affects the accuracy of the reading you will get from the hydrometer.

c. There are two common types of hydrometers:

- Temperature-compensating—Automatically adjust readings for electrolyte temperatures above or below 80°F.
- Non-temperature compensating—Require you to check electrolyte temperature and then perform mathematical calculation for electrolyte temperatures above or below 80°F.
  - For every 10 degrees of electrolyte temperature above 80 degrees, four gravity points (.004) must be added to the hydrometer's specific-gravity reading.
  - For every 10 degrees of electrolyte temperature below 80 degrees, four gravity points must be subtracted from the hydrometer's specific-gravity reading.

d. Use Table 2 below to convert the temperature-compensated readings of each cell into a state-of-charge percentage reading.

Table 2--Specific-gravity/state-of-charge chart

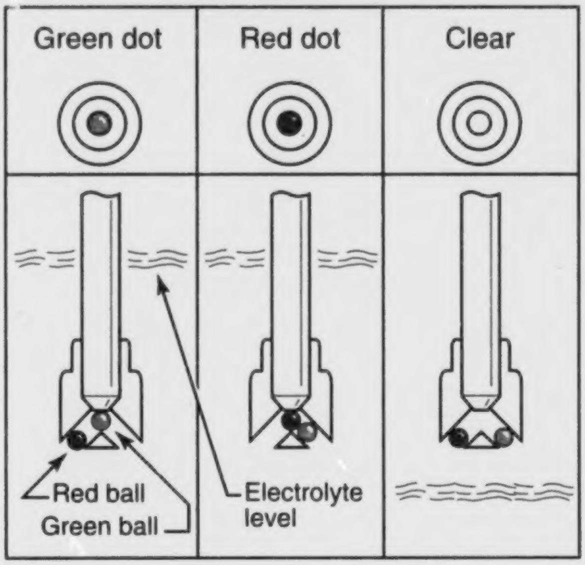
% Charged	Dry Charge or Wet Process (1.265 Full Charge)	Spin Processed (1.250 Full Charge)	Tropical (1.225 Full Charge)	Arctic (1.290 Full Charge)
100	1.265	1.250	1.225	1.290
95	1.250	1.235	1.210	1.275
75	1.230	1.220	1.180	1.255
50	1.200	1.190	1.130	1.225
25	1.170	1.160	1.090	1.195
Discharged	1.140	1.130	1.045	1.165

e. The readings for all the cells must be within the range given for normally charged cells of each battery type, and the cell readings must all be within 0.050 points of each other. If the cell readings do not meet both of these requirements, you must charge the battery and then retest the battery's state of charge. If the cell readings still do not meet these requirements, you must replace the battery.

f. Sealed batteries are designed with a special hydrometer that is built into the battery case. As the battery's state of charge changes, red and green balls move up and down inside the hydrometer cage.

Figure 35

Sight-glass appearance



(a) State of charge 65% or above–green dot appears in sight glass

(b) State of charge below 65%–red dot appears in sight glass

(c) Low electrolyte level–sight glass appears clear or light yellow

g. A battery charger is commonly used to increase the percentage of charge on a weak battery. The charger is adjusted somewhere in the 3- to 10- or 15-ampere range—5 amperes being typical. Check the charger manufacturer's specifications for recommended settings.

h. Charging rates and times depend on:

- The **battery's size or electrical capacity in ampere-hours**. (A completely discharged 70-AH battery requires almost twice the recharging time and rate as a completely discharged 40-AH battery.)
- **The temperature of the battery's electrolyte**. (It takes about two hours longer to charge a battery with an electrolyte temperature at 0°F than at 80°F.)
- **The battery's state of charge**. (A completely discharged battery requires twice as much charge as a battery that is half discharged.)
- **The battery's age and condition**. (A battery that has seen much service will require a higher rate of charge for a longer time than will a relatively new battery.)
- **The battery type**. (Sealed batteries usually require a longer, more constant rate of charge than a conventional battery. Some chargers will even have a switch indicating the type of battery to be charged.)

i. A conventional battery is considered fully charged when all cells are gassing freely (but not spewing liquid electrolyte), specific gravity tests at between 1.260 and 1.280, and no change occurs in specific gravity readings when tested over a three-hour period after the charging procedure.

j. A sealed battery is considered fully charged when the green dot is visible in the hydrometer's sight glass.

k. A battery load test is used to measure a battery's ability to deliver energy while it is working under a load.

l. A volt-amp tester is commonly used to load test a battery. During use, the volt amp tester leads are connected to the battery terminals, and then the load-control knob is turned, adjusting the load placed on the battery until a specified current shows on the ammeter. The voltmeter is then read to obtain a measure of the battery's voltage after the load has been maintained for 15 seconds.

m. Check the battery manufacturer's specifications or the equipment manufacturer's service manual for (1) how much load to place on the battery and (2) how to interpret the results on the battery test.

Objective 20

Battery safety practices

a. Always wear safety glasses, rubber gloves, and a rubber apron when working with batteries.

> Caution: When working with batteries, you always run the risk of coming into contact with the acid inside the battery cells. It is strong enough to destroy clothing and burn eyes and skin.

b. Always keep a mixture of baking soda and water nearby when working with batteries.

Note: If electrolyte is accidentally spilled or splashed on clothing or skin or on a vehicle's metal surfaces, wash the exposed area with the baking soda and water solution to neutralize the acid and then rinse thoroughly with clean water.

c. Do not smoke near a battery on charge or recently charged.

Note: Charging batteries form gases, some of which are released through vent holes. When exposed to flames or sparks, they can ignite and cause an explosion.

d. Do not break live circuits at the battery.

Note: A spark usually occurs where the circuit is broken. This can ignite the gases around the battery.

e. When disconnecting battery cables, always disconnect the grounded-terminal (negative) cable clamp first, and when reconnecting cables, always reconnect the insulated-terminal (positive) cable clamp first.

> Caution: Disconnecting or connecting cable clamps improperly can cause electrical arcs which can ignite the gases around the battery.

f. When using a battery charger, make connections before plugging the charger into the shop's wall outlet.

g. Always turn off battery charger before disconnecting from battery.

h. Never lay any conductor across battery terminals.

i. Do not attempt to jump-start a battery that may be frozen.

> Caution: Attempting to jump-start a battery with frozen electrolyte can rupture the battery or cause it to explode.

j. When connecting jumper cables to a battery, always connect the ground to vehicle frame or engine away from the battery.

k. Never charge, test, or jump-start a sealed battery when the hydrometer appears clear or light yellow.

l. Never wear metal rings or jewelry near a battery.

Objective 21

Assignment Sheet 1—Solve Problems Using Ohm's Law

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

Basic Skills

Reading Mathematics Critical Thinking

Introduction

Knowing how to use Ohm's law can help the diesel equipment technician in a number of ways such as troubleshooting, selecting correct electrical parts, and designing electrical circuits. This assignment sheet will help you learn to apply Ohm's law.

Directions

Read the following problems and use the formula for Ohm's law to find the unknown values. Write your answers on the blanks provided. Show your work in the space provided with each problem.

1. A light circuit has a resistance of 3 ohms. A current of 4 amperes is needed to illuminate the light. What voltage is needed from the power source?

   Voltage = ______________________

2. A 12-volt battery is connected to a horn that requires 12 amperes of current. What resistance is needed in the circuit to ensure the correct amperage?

   Ohms = ______________________

3. An electric starter on a vehicle equipped with a twelve-volt battery needs 6 amperes to operate. If the resistance in the circuit is 2.6 ohms, will there be enough current to operate the starter?

   Amperage required = ____________________

4. A windshield wiper in a 12-volt system requires 4 amps. If the circuit offers 2.9 ohms of resistance, will high resistance be a problem?

   Resistance required = ____________________

5. How many amperes are needed to power a lamp in a 12-volt circuit with five ohms of resistance?

   Amperage needed = ____________________

776

Objective 22

Assignment Sheet 2—Interpret Electrical Values from Multimeter Settings

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

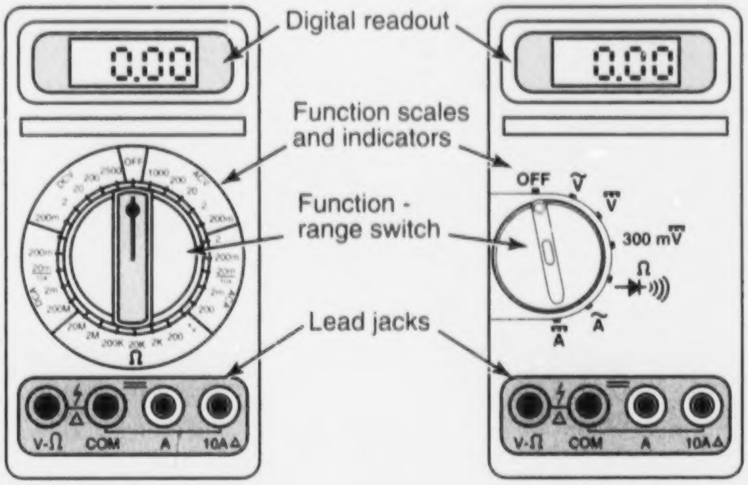
Basic Skills

Reading Mathematics Critical Thinking

Introduction

A typical digital multimeter, such as the one illustrated in Figure 1, has four major areas: (1) a digital display, (2) function scales and indicators, (3) a function-range switch, and (4) lead jacks. When the meter is in use, the function-range switch is turned to one of the six meter scales or indicators, the meter leads are connected to the circuit under test, and then a reading appears on the digital display.

Figure 1


Digital readout
0.00
0.00
Function scales and indicators
Function - range switch
OFF
300 mV
Ω
Lead jacks
V-Ω
COM
A
10A

Assignment Sheet 2

To obtain a correct reading from the digital display, you must be aware of the purposes of each function-range scale or indicator. Using Figure 2 as a reference and reading clockwise on the illustration, match the various scales and indicators with their purposes given below.

a. The OFF indicator is used between testing procedures to conserve the meter's battery without completely turning the meter off at the power switch.

b. The ACV scale is used to check alternating-current voltage.

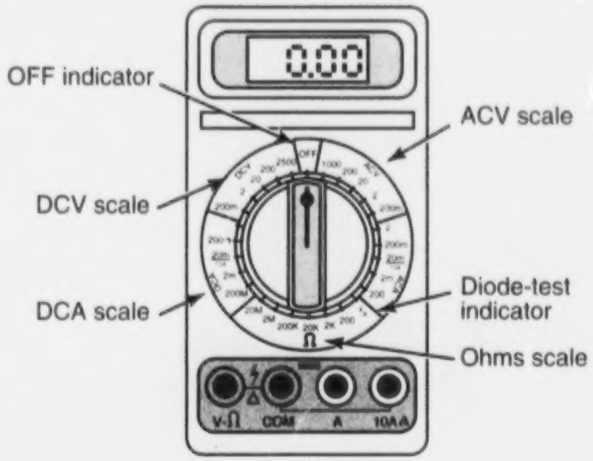
c. The diode-test indicator is used to check diodes for shorts or opens.

d. The ohms scale is used to make accurate measurements of in-circuit resistance or of electrical components out of the circuit.

e. The DCA scale is used to check direct-current amperage.

f. The DCV scale is used to measure available voltage in direct-current circuits.

Figure 2

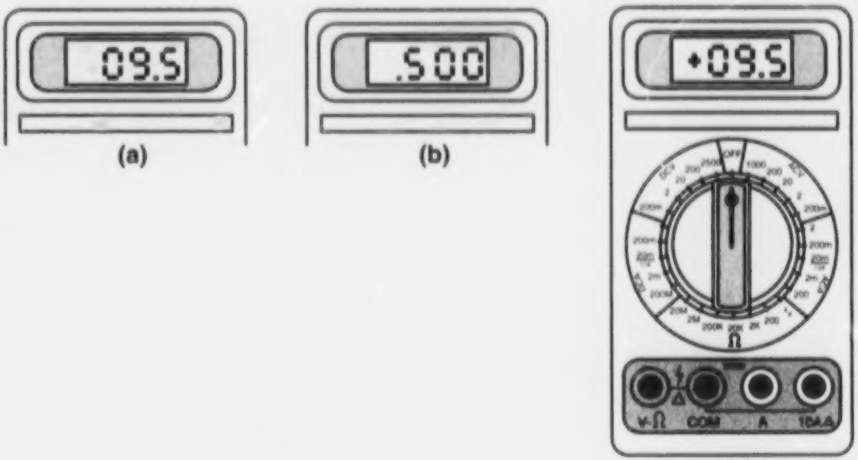


Reading the digital display

Reading the digital display for **voltage** and **amperage** measurements is simple—the display is read directly, regardless of where the function-range switch is set on the scale. For example, see Figure 3a and 3b. When 09.5 appears on the display, as in Figure 3a, the display is read as "nine point five volts or amps," depending on the function-range-switch setting. Notice that the zero in front of the nine is ignored. When .500 appears on the display, as in Figure 3b, the display is read as "point five volts or amps," depending on the function-range-switch setting. Remember, the zeroes count only when they are between a number and a decimal point.

In the DCV function, a plus (+) or a minus (–) symbol will also appear to the left side of the readout (see Figure 3c). These symbols indicate circuit polarity and are read as "volts positive" or "volts negative." For example, +9.5 is read as "nine point five volts positive."

Figure 3

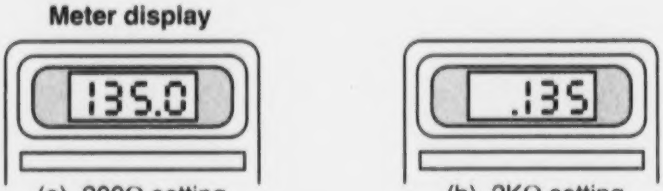


(c)

Reading the digital display for ohms is somewhat more complicated. On the ohms scale there are five range settings: 200Ω, 2KΩ, 20KΩ, 200KΩ, and 2000KΩ. The display for the 200Ω setting is the only ohms display that can be read directly (see Figure 4a). When 135 appears on the display at the 200Ω setting, the display is read as "one hundred thirty-five ohms." When the meter is at the 2KΩ, 20KΩ, 200KΩ, or 2000KΩ setting, some simple math must be done to obtain a correct reading. At 2KΩ, the reading must be multiplied by 1000 to obtain a correct reading; at 20KΩ, by 10,000; at 200KΩ, by 100,000; and at 2000KΩ, by 1,000,000.

For example, when .135 appears on the display at the 2KΩ setting, the reading must be multiplied by 1000 (or the decimal must be moved over three places to the right) to obtain the correct reading of "one hundred thirty-five ohms" (see Figure 4b).

Figure 4



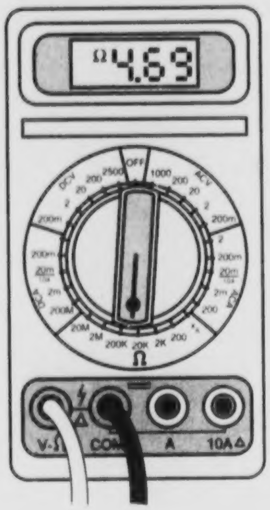
(a) 200Ω setting
Resistance = 135 ohms

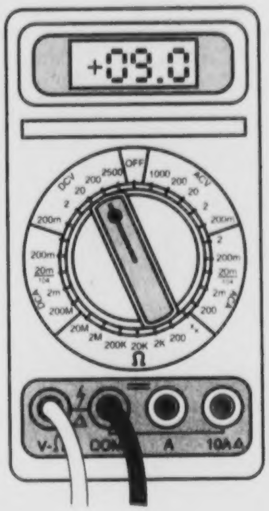
(b) 2KΩ setting
Resistance = .135 x 1000 = 135 ohms

Assignment Sheet 2

Directions

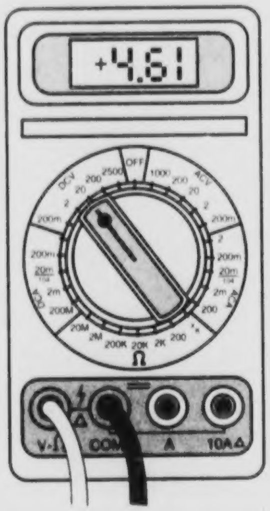
Study each of the digital multimeters illustrated below to determine the function-range setting, and then read the display for the meters. Write the correct meter reading on the blanks provided under the illustrations.

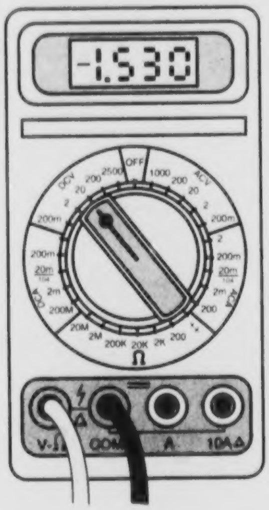

Ω4.69
OFF
2500
1000
200
DCV
ACV
20
2
200m
20m
2m
DCA
ACA
200M
20M
2M
200K
20K
2K
200
Ω
V-Ω
COM
A
10A


+09.0
OFF
2500
1000
200
DCV
ACV
20
2
200m
20m
2m
DCA
ACA
200M
20M
2M
200K
20K
2K
200
Ω
V-Ω
COM
A
10A

1. ______________________________

2. ______________________________

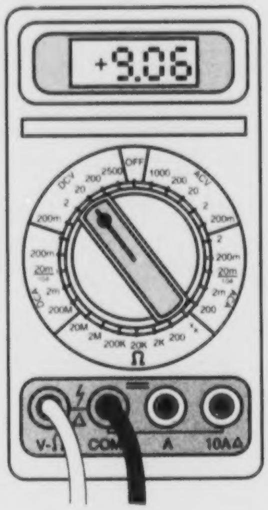

+4.61
OFF
2500
1000
200
DCV
ACV
20
2
200m
20m
2m
DCA
ACA
200M
20M
2M
200K
20K
2K
200
Ω
V-Ω
COM
A
10A


-1.530
OFF
2500
1000
200
DCV
ACV
20
2
200m
20m
2m
DCA
ACA
200M
20M
2M
200K
20K
2K
200
Ω
V-Ω
COM
A
10A

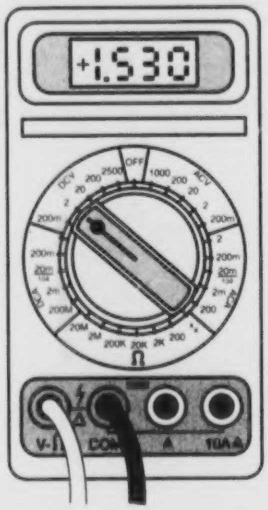
3. ______________________________

4. ______________________________

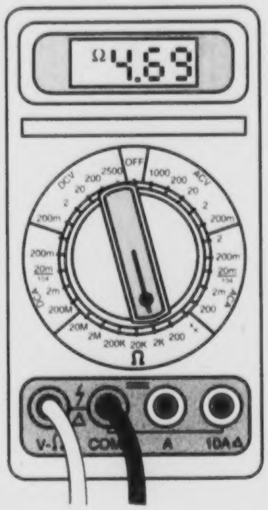
780


+9.06
OFF
DCV
ACV
DCA
ACA
Ω
V-Ω
COM
A
10A

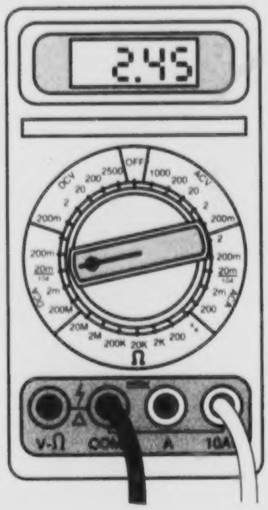
5. ______________________


+1.530
OFF
DCV
ACV
DCA
ACA
Ω
V-Ω
COM
A
10A

6. ______________________

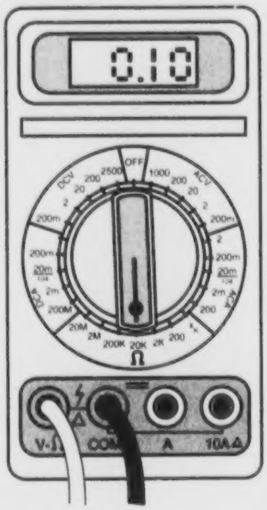

Ω 4.69
OFF
DCV
ACV
DCA
ACA
Ω
V-Ω
COM
A
10A

7. ______________________

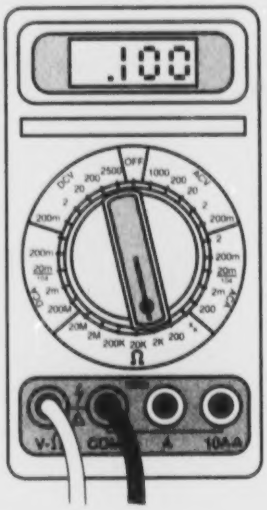

2.45
OFF
DCV
ACV
DCA
ACA
Ω
V-Ω
COM
A
10A

8. ______________________

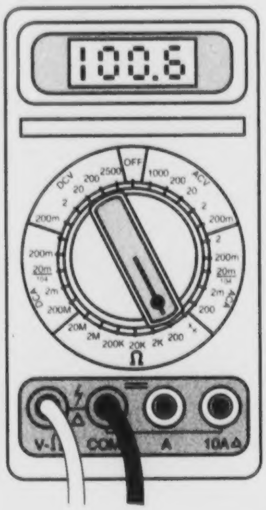
Assignment Sheet 2


0.10
OFF
DCV
ACV
DCA
ACA
Ω
V-Ω
COM
A
10A

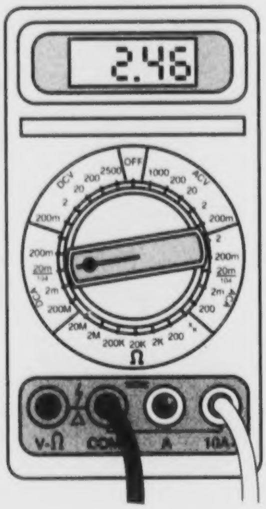
9. ______________________________


.100
OFF
DCV
ACV
DCA
ACA
Ω
V-Ω
COM
A
10A

10. ______________________________


100.6
OFF
DCV
ACV
DCA
ACA
Ω
V-Ω
COM
A
10A

11. ______________________________


2.46
OFF
DCV
ACV
DCA
ACA
Ω
V-Ω
COM
A
10A

12. ______________________________

Objective 23

Assignment Sheet 3—Interpret Wiring Diagrams

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Directions are followed	______
• Answers are correct	______

Basic Skills

Reading

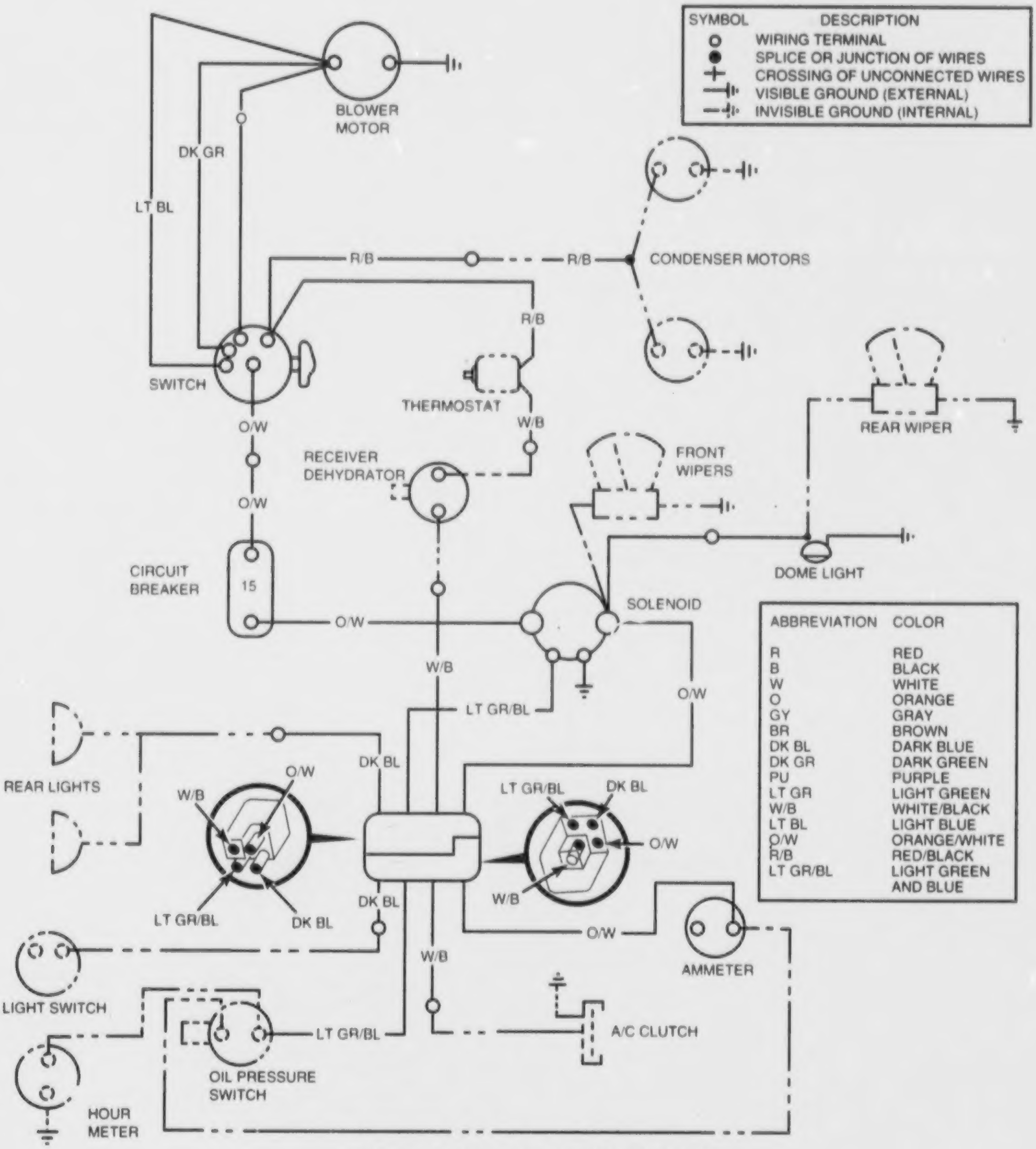
Critical Thinking

Directions

Study the cab wiring diagrams for a Caterpillar D5B Tractor in Figures 1 and 2. Answer the questions regarding the diagrams and write your answers in the blanks provided.

1. Is the white and black striped wire that runs from the electrical box to the receiver dehydrator connected to the orange and white wire between the circuit breaker and the solenoid? ______________
2. Is power to the front wipers routed directly from the battery or from ground? ______________
3. What component is on the same circuit as the rear wiper? ______________
4. Is there a wiring terminal between the circuit breaker and the blower motor switch? ______________
5. How many front windshield wipers does the tractor have? ______________
6. What color is the wire from the pump to the rear wiper switch? ______________
7. How many positions are on the front left-side wiper switch? ______________
8. Are the front wipers wired in series or parallel? ______________
9. How many amperes can the circuit carry before it throws the circuit breaker? ______________
10. An electronic device is on the orange and white wire between the electrical box and the oil pressure switch. What is the name of the device? ______________

Figure 1


BLOWER MOTOR
DK GR
LT BL
R/B
R/B
CONDENSER MOTORS
R/B
SWITCH
THERMOSTAT
W/B
O/W
RECEIVER DEHYDRATOR
O/W
FRONT WIPERS
REAR WIPER
DOME LIGHT
CIRCUIT BREAKER
15
O/W
SOLENOID
W/B
LT GR/BL
O/W
REAR LIGHTS
DK BL
O/W
W/B
LT GR/BL
DK BL
LT GR/BL
DK BL
O/W
W/B
DK BL
W/B
O/W
AMMETER
LIGHT SWITCH
LT GR/BL
A/C CLUTCH
OIL PRESSURE SWITCH
HOUR METER

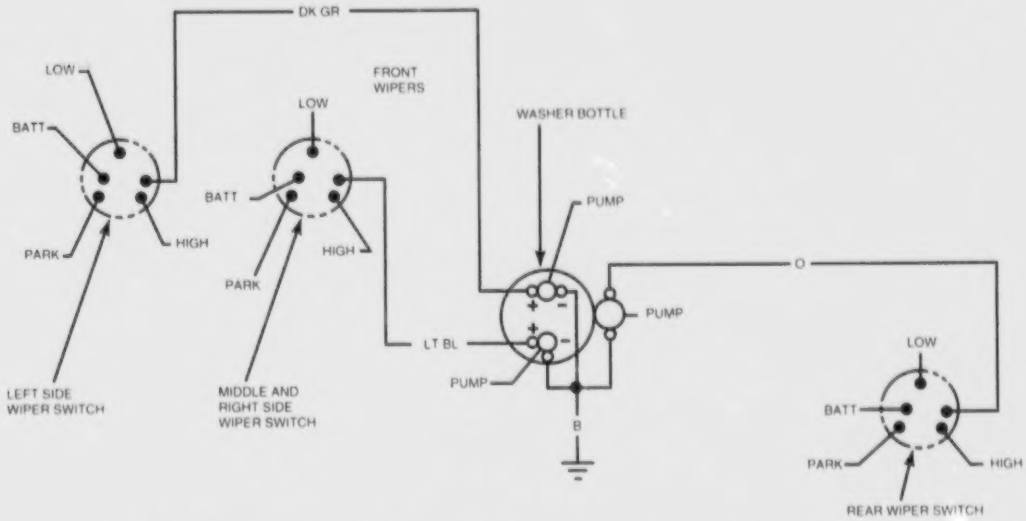
SYMBOL	DESCRIPTION
○	WIRING TERMINAL
●	SPLICE OR JUNCTION OF WIRES
+	CROSSING OF UNCONNECTED WIRES
—⊪	VISIBLE GROUND (EXTERNAL)
–⊪	INVISIBLE GROUND (INTERNAL)

ABBREVIATION	COLOR
R	RED
B	BLACK
W	WHITE
O	ORANGE
GY	GRAY
BR	BROWN
DK BL	DARK BLUE
DK GR	DARK GREEN
PU	PURPLE
LT GR	LIGHT GREEN
W/B	WHITE/BLACK
LT BL	LIGHT BLUE
O/W	ORANGE/WHITE
R/B	RED/BLACK
LT GR/BL	LIGHT GREEN AND BLUE

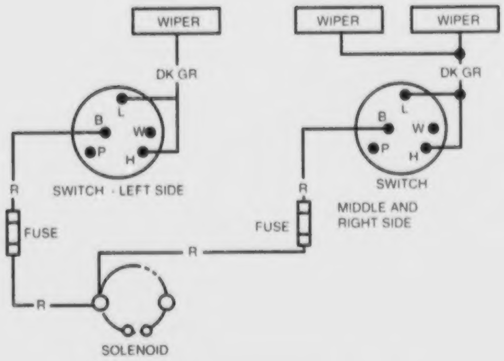
CAB ELECTRICAL SCHEMATIC

784

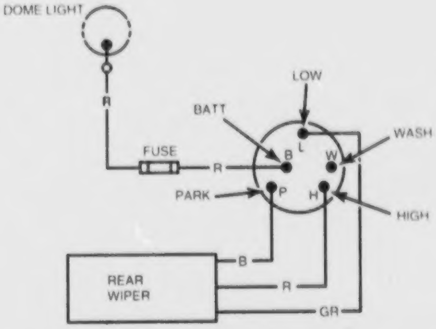
Figure 2


DK GR
LOW
BATT
PARK
HIGH
LEFT SIDE WIPER SWITCH
FRONT WIPERS
LOW
BATT
PARK
HIGH
MIDDLE AND RIGHT SIDE WIPER SWITCH
WASHER BOTTLE
PUMP
LT BL
PUMP
PUMP
B
O
LOW
BATT
PARK
HIGH
REAR WIPER SWITCH

WINDSHIELD WASHER ELECTRICAL SCHEMATIC


WIPER
DK GR
B
L
W
P
H
SWITCH - LEFT SIDE
R
FUSE
R
WIPER
WIPER
DK GR
B
L
W
P
H
SWITCH
MIDDLE AND RIGHT SIDE
R
FUSE
R
SOLENOID

FRONT WINDSHIELD WIPER ELECTRICAL SCHEMATIC


DOME LIGHT
R
LOW
BATT
WASH
FUSE
R
B
L
W
PARK
P
H
HIGH
REAR WIPER
B
R
GR

REAR WINDSHIELD WIPER ELECTRICAL SCHEMATIC

Objective 24

Job Sheet 1—Measure Current, Voltage, and Resistance With a Multimeter

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Followed correct procedure for measuring circuit current	______
• Recorded correct amperage reading	______
• Followed correct procedure fo rmeasuring circuit voltage	______
• Recorded correct voltage reading	______
• Followed correct procedures for measuring resistance	______
• Recorded correct ohms reading	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Multimeter
- Multimeter manufacturer's instruction book
- Diesel electrical circuit
- Diesel manurfacturer's reference manual

Procedure

Measuring circuit current (amps)

☐ 1. Check service manual for wiring diagram of circuit under test to determine:

   a. Range of circuit under test

   Note: This information is not always given on the wiring diagram.

   b. Procedure for opening circuit under test

   c. Best test location for circuit under test (where to attach meter in circuit)

☐ 2. Check meter manufacturer's instruction manual to determine:

  a. Proper meter scale for measuring amps (analog meter)

  b. Proper meter setting for measuring amps in circuit under test

  Note: Most hand-held meters are capable of measurements in the 10-amp range. You may have to obtain a special shunted meter, such as a VAT-40, for certain diesel circuits.

  c. Procedure for plugging test probes into meter for measuring amps

☐ 3. Open circuit under test as directed in service manual. (step 1)

☐ 4. Plug test probes into meter as directed in meter manufacturer's instruction manual. (step 2)

☐ 5. If service manual wiring diagram lists range of circuit under test, set meter range-selector switch to correct position for circuit under test.

☐ 6. If service manual wiring diagram does not list range of circuit under test (you are working with unknown currents), set meter range-selector switch on highest setting.

> Caution: Setting the meter on too low a setting could damage the meter.

☐ 7. Attach test probes in **series** at circuit test location determined in step 1.

☐ 8. If using an analog meter, check to be sure you are using proper meter scale for amps reading.

☐ 9. If you are unable to get a meter reading, position range-selector switch at progressively lower settings until reading is achieved.

☐ 10. If meter reads backwards, reverse probes and take another reading.

Note: If an analog meter is reading backwards, the needle will swing to the left. If a digital meter is reading backwards, the display will show a negative reading.

☐ 11. Record reading when obtained.

☐ 12. Report reading to your instructor.

787

Procedure

Measuring circuit voltage (volts)

☐ 1. Check service manual for wiring diagram of circuit under test to determine:

   a. Range of circuit under test

   Note: This information is not always given on the wiring diagram.

   b. Procedure for opening circuit under test

   c. Best test location for circuit under test

☐ 2. Check meter manufacturer's instruction manual to determine:

   a. Proper meter scale for measuring volts (analog meter)

   b. Proper meter setting for measuring volts in circuit under test

   c. Procedure for plugging test probes into meter for measuring volts

☐ 3. Open circuit under test as directed in service manual. (step 1)

☐ 4. Plug test probes into meter as directed in meter manufacturer's instruction manual. (step 2)

☐ 5. If service manual wiring diagram lists range of circuit under test, set meter range-selector switch to correct position for circuit under test.

☐ 6. If service manual wiring diagram does not list range of circuit under test, set meter range-selector switch at a position slightly greater than 12 volts.

Note: Since most diesel electrical systems operate on 12 volts, setting the switch at a setting slightly higher than 12 volts will protect the meter from damage.

☐ 7. Attach test probes **in parallel** at circuit test location determined in step 1.

☐ 8. If using an analog meter, check to be sure you are using proper meter scale for volts reading.

☐ 9. If you are unable to get a meter reading, position range-selector switch at progressively lower settings until reading is achieved.

☐ 10. If meter reads backwards, reverse probes and take another reading.

Note: If an analog meter is reading backwards, the needle will swing to the left. If a digital meter is reading backwards, the display will show a negative reading.

☐ 11. Record reading when obtained.

☐ 12. Report reading to your instructor.

Procedure

Measuring circuit resistance (ohms)

☐ 1. Check service manual for wiring diagram of circuit under test to determine:

  a. Range of circuit under test

  Note: This information is not always listed on the wiring diagram.

  b. Power source for circuit under test

  c. Procedure for opening circuit under test

  d. Best test location for circuit under test

☐ 2. Check meter manufacturer's instruction manual to determine:

  a. Procedure for zeroing meter for ohms reading

  b. Proper meter scale for measuring ohms (analog meter)

  c. Procedure for plugging test probes into meter for measuring ohms

  d. Proper meter setting for measuring ohms in circuit under test

☐ 3. Zero meter following manufacturer's instructions. (step 2)

Note: You must make a zero-ohms adjustment each time you move the range-selector switch to a new resistance position.

☐ 4. If meter is at zero-ohms reading, continue testing procedure.

☐ 5. If meter is not at zero-ohms reading, follow manufacturer's instructions for adjusting meter to zero reading.

☐ 6. Turn off power to circuit under test. (step 1)

Caution: When working with an ohmmeter, the power must be off in the circuit under test. Damage to the meter will result if the power to the circuit is not off.

☐ 7. Open circuit under test. (step 1)

☐ 8. Plug test probes into meter as directed in manufacturer's instruction manual. (step 2)

☐ 9. If service manual wiring diagram lists range of circuit under test, set range-selector switch to the correct position for circuit.

☐ 10. If service manual wiring diagram does not list range of circuit under test, set meter range-selector on lowest setting.

☐ 11. Attach test probes **in parallel** at circuit test location determined in step 1.

☐ 12. If using an analog meter, check to be sure you are using proper meter scale for ohms reading.

☐ 13. If you are unable to get a meter reading, position range-selector switch at progressively higher settings until reading is achieved.

☐ 14. Record reading when obtained.

☐ 15. Report reading to your instructor.

☐ 16. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 25

Job Sheet 2—Test and Replace Light Bulbs and Test Sockets

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Followed correct procedure for exposing and inspecting bulb	______
• Obtained proper replacement bulb as necessary	______
• Followed correct procedure for testing socket	______
• Followed correct procedure for installing bulb and socket	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Diesel lighting circuit
- Diesel service manual and wiring diagram
- Light-bulb pliers
- Appropriate screwdriver
- Socket-cleaning brush

Procedure

Exposing and inspecting bulb

☐ 1. Make sure switch that operates bulb is turned off.

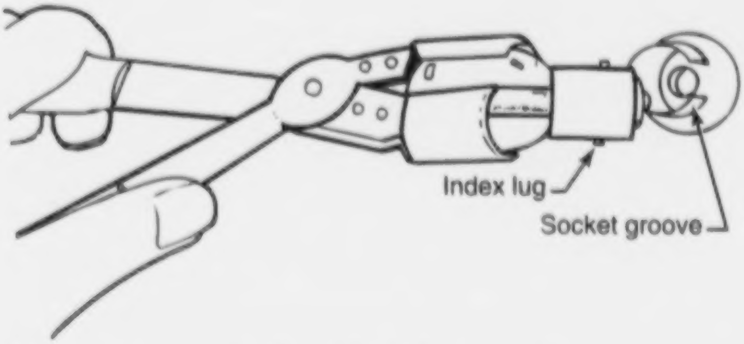
> Caution: The switch must be turned off to prevent a short while you expose the bulb and clean the light socket.

☐ 2. Expose the bulb for inspection. Check service manual to determine proper method of exposing bulb for removal from its socket.

☐ 3. Remove exposed bulb from socket: Using light-bulb pliers, turn bulb about 1/4 turn to unlock index lugs from socket groove, then pull bulb straight out of socket.

Caution: Do not use your fingers to remove a bulb from its socket. Use light-bulb pliers to protect your fingers from broken glass should the bulb break during removal.

Figure 1



Adapted with permission of the State of Florida, Department of State.

☐ 4. Inspect bulb:

a. For signs of corrosion on bulb base. If base is corroded, clean with sandpaper.

b. For signs that glass is loose from bulb base. If so, check service manual and obtain proper replacement bulb.

☐ 5. If original bulb does not appear defective, test light bulb with ohmmeter or ohmmeter function of multimeter.

☐ 6. If original bulb tests defective, check service manual for proper replacement bulb and obtain.

☐ 7. Inspect socket housing for signs of corrosion, and clean socket with socket-cleaning brush if necessary.

☐ 8. Insert replacement bulb or original bulb into light socket, making sure bulb index lugs fit into socket grooves properly.

Note: If the index lugs are offset, one groove in the socket will be deeper than the other. This lets you know you have installed the wrong bulb.

☐ 9. Turn on switch that operates bulb to test that bulb will now light.

☐ 10. If bulb does light, turn off switch to light and restore bulb and socket to proper condition.

☐ 11. If bulb does **not** light, test socket to determine whether or not current is getting to socket.

Procedure

Testing single-terminal light socket (backup lights, side-marker lights)

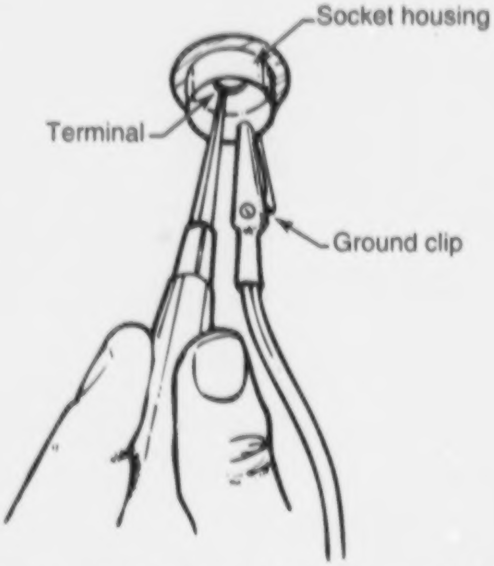
☐ 1. Remove bulb from socket.

☐ 2. Clip ground clip of 12-volt test light to socket housing or other good ground.

☐ 3. Touch sharp point of test-light probe to light-socket terminal. (Figure 2)

> Caution: Do not allow test-light probe to contact socket housing. This could cause a short that would blow fuses in the circuit.

Figure 2



Used with permission of the State of Florida, Department of State.

☐ 4. Record test results. If test light does not light up, electrical current is not present at socket; if test light does light up, electrical current is present at socket.

☐ 5. Notify instructor of test results.

☐ 6. Install bulb and socket in vehicle. Check service manual for proper method of installing bulb and socket.

☐ 7. Clean work area and return equipment and materials to proper storage.

Procedure

Testing dual-terminal light socket (stop lights, taillights, front parking lights, turn-signal lights)

☐ 1. Remove bulb from socket.

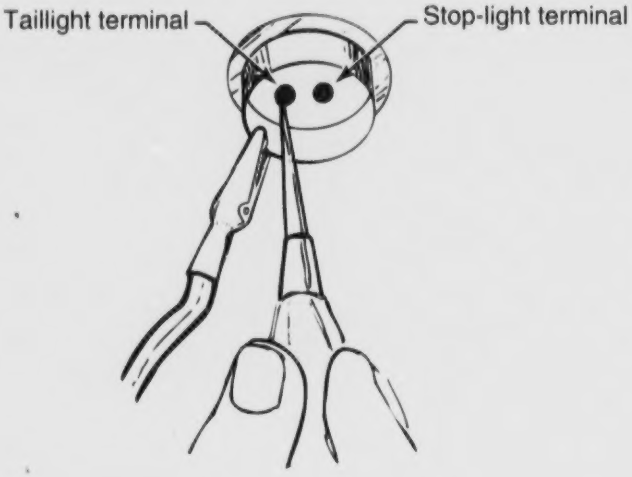
☐ 2. Clip ground clip of 12-volt test light to socket housing or other good ground.

☐ 3. Check vehicle wiring diagram to determine which terminal should be tested.

☐ 4. Touch sharp point of test-light probe to correct light-socket terminal. (Figure 3)

Caution: Do not allow test-light probe to contact socket housing. This could cause a short that would blow fuses.

Figure 3



☐ 5. Record test results. If test light does **not** light up, electrical current is not present at socket; if test light does light up, electrical current is present at socket.

☐ 6. Notify instructor of test results.

☐ 7. Install bulb and socket in vehicle. Check service manual to determine proper method of installing bulb and socket.

☐ 8. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 26

Job Sheet 3—Tin a Soldering Iron or Gun

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Tinned tip of gun correctly	______
• Demonstrated quality work throughout	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Soldering iron or gun (with replaceable tips)
- Solder, rosin-core on roll
- Clean, damp cloth or sponge

Note: Before a tip is used, it must be tinned—coated with a very thin film of solder.

Caution: Follow all shop safety procedures. Wear safety glasses.

Procedure

☐ 1. Before plugging in, inspect tip for proper wedge shape.

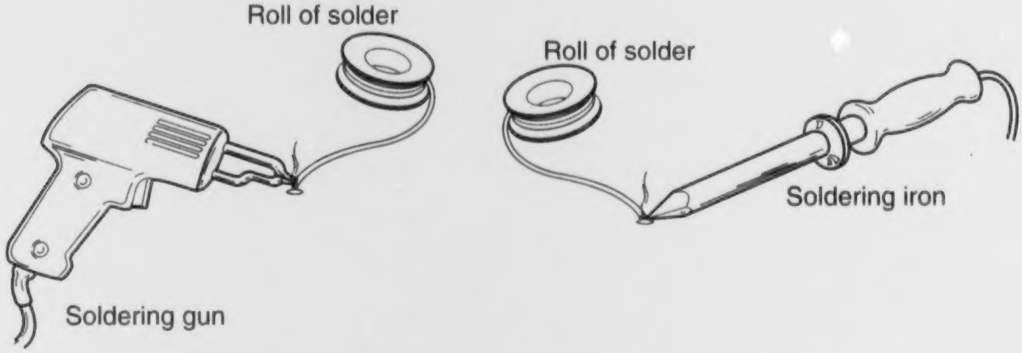
☐ 2. If tip is not properly wedge-shaped, check with your instructor to determine proper shaping procedure, and shape tip, removing as little metal as possible.

Note: Most tips can be shaped with file; however, irons or guns with iron-clad tips should not need reshaping. Normally, iron-clad tips are merely cleaned with a wire brush. Filing will shorten their useful life. Gold-plated tips are very expensive and should never be filed.

☐ 3. Place soldering iron/gun in holder, connect power cord to power receptacle, and allow iron/gun to heat.

☐ 4. Apply small amount of rosin-core solder directly to the tip.

Figure 1


Roll of solder
Roll of solder
Soldering iron
Soldering gun

☐ 5. Shake the tip slightly to remove excess solder.

☐ 6. Use a clean damp cloth or sponge to wipe off the soldering iron/gun after use.

> Caution: Keep iron/gun over cloth on work surface. Hot solder dripping from the soldering iron/gun can burn your skin or damage your clothing.

☐ 7. Disconnect power cord from power receptacle, place iron/gun in holder, and allow to cool.

☐ 8. Have instructor inspect soldering tip.

Evaluator's Comments: ____________________

____

____

797

Objective 27

Job Sheet 4—Solder-Splice Electrical Wiring

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Stripped wire and cleaned exposed wiring properly	______
• Prepared soldering iron or gun properly	______
• Followed correct procedure for solder splicing connection	______
• Reinsulated solder-spliced connection correctly	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Safety glasses
- Wire stripping and crimping tool
- Razor blade or cleaning-flux solution
- Soldering iron or gun
- Rosin-core solder
- Clean screwdriver
- Tinning oil or flux (soldering paste or liquid)
- Wet sponge or cloth
- Electrical tape or heat-shrink insulation and heat gun

Caution: Follow all shop safety procedures. Wear safety glasses.

Procedure

☐ 1. Determine wire gauge.

☐ 2. Test strip insulation.

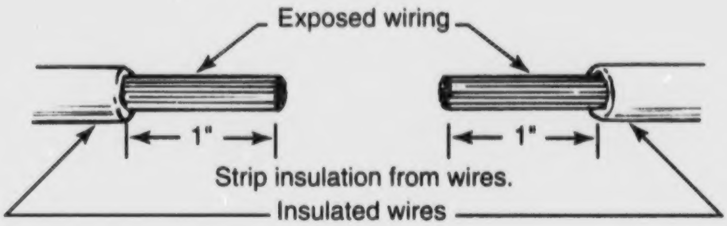
  ☐ a. Using correct gauge hole in stripping area of wire stripping and crimping tool, strip back insulation 3/8 inch from end of a wire.

  ☐ b. Check exposed wiring for cuts or nicks.

  ☐ c. If cuts or nicks occur, recheck for proper wire gauge and test again until insulation is removed without damaging exposed wiring.

☐ 3. Strip 1 inch of insulation from end of each wire to be solder-spliced.

Figure 1



☐ 4. Clean exposed wiring on small-gauge wire (16-gauge or smaller) with cleaning-flux solution; clean large-gauge wire by carefully scraping with a razor blade.

Caution: Take care not to cut or nick the wiring (or yourself).

☐ 5. Prepare soldering iron or gun tip for use as shown in Job Sheet 1.

☐ 6. If using heat-shrink insulation, cut and slide insulation onto one conductor.

Note: Slide tubing back far enough on the conductor to keep it from being heated during the soldering process.

☐ 7. Form spliced connection by gently twisting exposed wiring ends together. If stranded wire is involved, twist in direction of strand twist so that strands do **not** separate.

☐ 8. Using hot soldering iron or gun, heat exposed wiring and apply solder to spliced connection just until solder flows freely among all exposed wiring strands.

Caution: Do not build up solder on crimped connection. The solder-spliced connection will break if too much solder is applied. Do not move the solder-spliced wires until the solder has hardened and cooled. Moving the wires before the solder cools may break the connection.

☐ 9. Test cooled and hardened solder-spliced connection by attempting to pull connection apart by hand.

☐ 10. If connection seems loose, reheat wire to melt solder into the wires more thoroughly and retest when solder cools.

☐ 11. Have instructor inspect cooled and hardened solder-spliced connection.

☐ 12. When solder-spliced connection is secure, reinsulate connection by tightly wrapping with at least two layers of electrical tape or by applying heat to heat-shrink insulation.

Note: Use a heat gun to apply heat to heat-shrink insulation. Do not use a match. A match creates too much heat, which will make the tubing brittle and cause it to crack.

☐ 13. Have instructor inspect insulated connection.

☐ 14. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 28

Job Sheet 5—Install Terminals and Connectors

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Stripped wire and cleaned exposed wiring properly	______
• Followed correct procedure for installing a solderless connector or terminal	______
• Followed correct procedure for installing a soldered connector or terminal	______
• Reinsulated connection properly	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Terminals and connectors
- Eye protection
- Wire stripping and crimping tool
- Razor blade or cleaning flux solution
- Soldering iron or gun
- Rosin core solder
- Clean screwdriver
- Wet sponge
- Electrical tape or heat-shrink insulation and heat gun

Procedure

Installing a solderless conductor or terminal

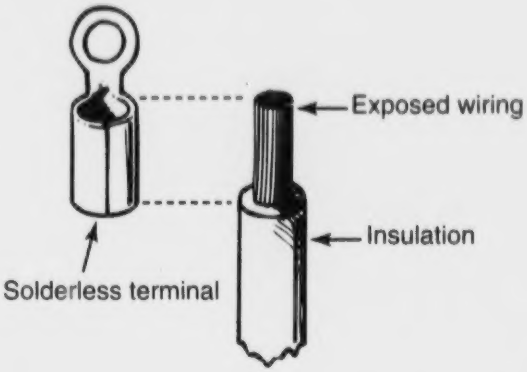
☐ 1. Determine wire gauge.

☐ 2. Select connector or terminal to match wire gauge.

☐ 3. Test-strip insulation from wiring until insulation is removed without damaging exposed wiring.

☐ 4. Strip insulation from end of wire to expose enough wiring to permit installation of connector or terminal.

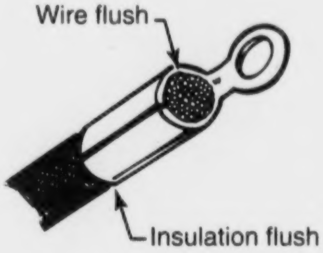
Figure 1



☐ 5. Test-fit wiring in terminal or connector.

Note: The insulation on the wire should be cut so that it will butt squarely against the terminal or connector and be stripped to a length so that the exposed wiring will enter the terminal or connector completely. If the insulation does not butt squarely, it should be recut, and if too much insulation has been removed, the wiring should be trimmed.

Figure 2



☐ 6. If necessary, correct cut and trim wire.

☐ 7. Clean exposed wiring on small-gauge wire (16-gauge or smaller) with cleaning-flux solution; clean larger-gauge wiring by carefully scraping with razor blade.

Caution: Take care not to cut or nick the wiring (or yourself).

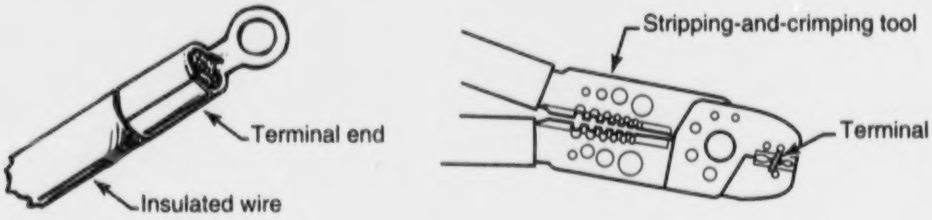
☐ 8. If using heat-shrink insulation, cut and slide insulation onto conductor.

☐ 9. Clean terminal or connector with sandpaper.

802

☐ 10. Place exposed wiring into terminal or connector, and form crimped connection using crimping area of wire-stripping-and-crimping tool.

Figure 3


Terminal end
Insulated wire
Stripping-and-crimping tool
Terminal

☐ 11. Test crimped connection by pulling on the wire.

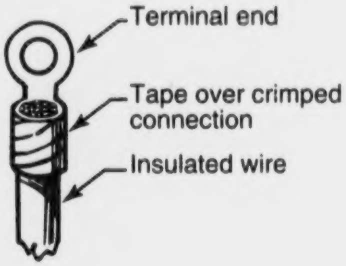
Note: You should not be able to pull the wire out of a good crimped connection.

☐ 12. If crimped connection is secure, have instructor check connection.

☐ 13. Insulate crimped connection by tightly wrapping with at least two layers of electrical tape or by applying heat to heat-shrink insulation.

Note: Use a heat gun to apply heat to heat-shrink insulation. Do not use a match. A match creates too much heat, which will make the tubing brittle and cause it to crack.

Figure 4


Terminal end
Tape over crimped connection
Insulated wire

Procedure

Installing a soldered terminal or connector

☐ 1. Follow steps 1 through 12 for installing a solderless terminal or connector.

☐ 2. Prepare soldering-iron or -gun tip for use. (see Job Sheet 1)

☐ 3. Plug soldering-iron or -gun power cord into power receptacle and allow to heat.

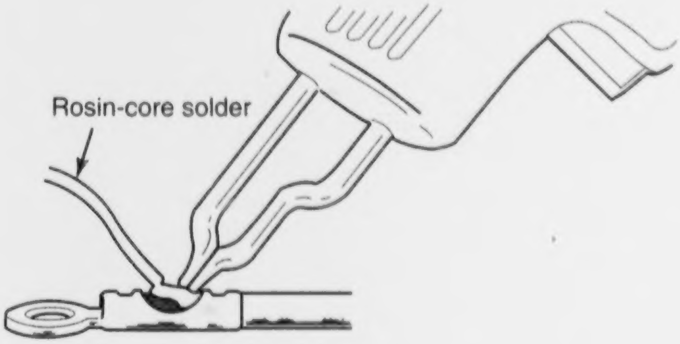
☐ 4. If using heat-shrink insulation, cut and slide insulation onto conductor.

Note: Slide tubing back far enough on the conductor to keep it from heating during the soldering process.

☐ 5. When iron or gun is hot, heat exposed wiring and apply rosin-core solder to crimped connection, applying only enough solder to attach terminal or connector securely.

Caution: Do not build up solder on crimped connection. The connection will break if too much solder is applied. Do not move the connection until the solder has hardened and cooled. Moving the connection before the solder cools may break the connection.

Figure 5



☐ 6. Test cooled and hardened connection by attempting to pull connection apart by hand.

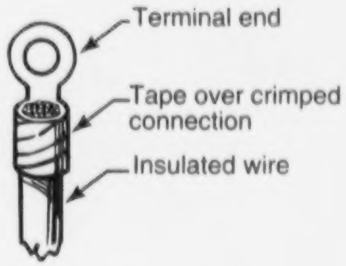
☐ 7. If connection seems loose, reheat wire to melt solder more thoroughly and retest when solder cools.

☐ 8. When connection is secure, have instructor inspect cooled and hardened soldered connection.

☐ 9. Insulate soldered connection by tightly wrapping with at least two layers of electrical tape or by applying heat to heat-shrink insulation.

Note: Use a heat gun to apply heat to heat-shrink insulation. Do not use a match. A match creates too much heat, which will make the tubing brittle and cause it to crack.

Figurè 6


Terminal end
Tape over crimped connection
Insulated wire

☐ 10. Have instructor inspect insulated connection.

☐ 11. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ____________________

____

____

Objective 29

Job Sheet 6—Test Charge a Conventional (Non-sealed) Battery

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Prepared vehicle for test properly	______
• Prepared battery for test properly	______
• Followed correct procedure for obtaining hydrometer readings	______
• Recorded correct readings	______
• Interpreted test results properly	______
• Selected correct replacement battery as necessary	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Conventional battery
- Hydrometer
- Specific-gravity/state-of-charge chart
- Fender covers
- Shop towels and brush
- Water container
- Eye protection
- Rubber apron
- Rubber gloves
- Pencil and paper

Procedure

☐ 1. Put on eye protection, rubber gloves, and rubber apron.

☐ 2. If battery to be tested is in vehicle, place fender covers over fenders.

☐ 3. Perform visual inspection of battery. Clean battery if necessary.

☐ 4. Remove battery filler caps.

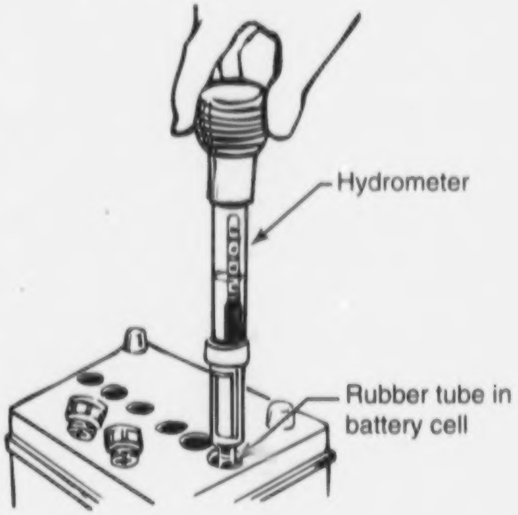
☐ 5. Squeeze hydrometer bulb.

☐ 6. Insert rubber hydrometer tube into electrolyte in filler hole over first battery cell.

☐ 7. Slowly release rubber bulb to draw proper amount of electrolyte into hydrometer.

Note: Do not lift hydrometer out of electrolyte.

Figure 1

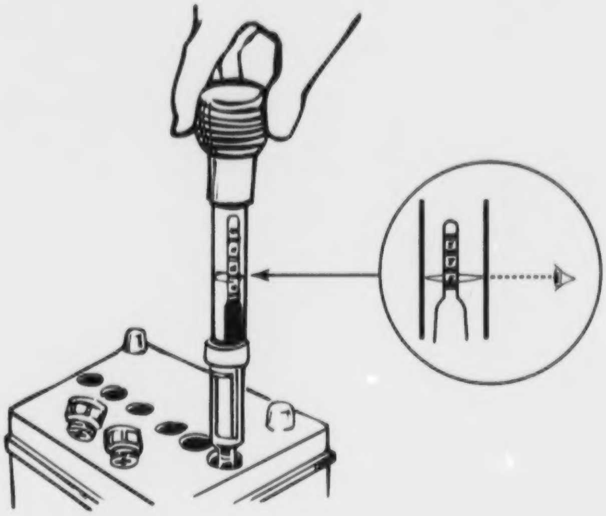


☐ 8. Check to be certain that hydrometer is clean and functioning properly. The float should be suspended in the electrolyte; it should not bump the top of the hydrometer tube or stick to the side.

☐ 9. Holding the hydrometer level, bend down until you are at eye level with hydrometer scale; take reading.

807

Figure 2



☐ 10. Record reading.

☐ 11. Squeeze bulb to return electrolyte to cell.

☐ 12. Repeat steps 5 through 11 for each battery cell.

☐ 13. Replace filler caps.

☐ 14. If using a non-temperature-compensating hydrometer, adjust readings for temperature and record.

  ☐ a. Add four gravity points (.004) for every 10 degrees above 80 degrees.

  ☐ b. Subtract four gravity points (.004) for every 10 degrees below 80 degrees.

☐ 15. Interpret test results.

  ☐ a. Check specific-gravity chart to determine battery state-of-charge percentage.

Table 1—Specific-gravity/state-of-charge chart

% Charged	Dry Charge or Wet Process (1.265 Full Charge)	Spin Processed (1.250 Full Charge)	Tropical (1.225 Full Charge)	Arctic (1.290 Full Charge)
100	1.265	1.250	1.225	1.290
95	1.250	1.235	1.210	1.275
75	1.230	1.220	1.180	1.255
50	1.200	1.190	1.130	1.225
25	1.170	1.160	1.090	1.195
Discharged	1.140	1.130	1.045	1.165

☐ b. If cell readings are all within range given for normally charged cells of battery type, and all are within 0.050 points of each other, record state-of-charge reading, clean battery, and return to service.

☐ c. If cell readings do **not** meet both requirements in step b, record state of charge, slow charge battery (Job Sheet 8), and then retest state of charge.

☐ d. If cell readings still do not meet requirements, replace battery.

☐ 16. Report test results to instructor.

☐ 17. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

809

Objective 30

Job Sheet 7—Test Charge a Sealed Battery

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Prepared vehicle for test properly	______
• Prepared battery for test properly	______
• Followed correct procedure for obtaining hydrometer readings	______
• Recorded correct readings	______
• Interpreted test results properly	______
• Selected correct replacement battery as necessary	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Sealed battery
- Fender covers
- Shop towels and brush
- Water container
- Eye protection
- Rubber apron
- Rubber gloves
- Flashlight
- Small screwdriver
- Pencil and paper

Procedure

☐ 1. Put on eye protection, rubber gloves, and rubber apron.

☐ 2. If battery is under the vehicle's hood, place fender covers over fenders.

☐ 3. Perform visual inspection of battery; clean battery if necessary.

☐ 4. Locate battery's built-in hydrometer.

☐ 5. Look straight down into hydrometer, using flashlight beam if necessary in poorly lit area.

- ☐ 6. Determine battery state of charge.
    - ☐ a. If green dot shows in hydrometer sight glass, battery state of charge is at 65 percent or above, and battery is charged enough for further testing.
    - ☐ b. If red dot shows in sight glass, battery is below 65 percent state of charge and must be slow-charged (Job Sheet 8) before further testing is performed.
    - ☐ c. If hydrometer appears clear or light yellow, electrolyte level may be low and battery may need to be replaced. Tap hydrometer lightly with a small screwdriver to dislodge any gas bubbles that may be giving a false indication of low electrolyte level. If clear or light yellow appearance remains, battery must be replaced.
- ☐ 7. Record battery state of charge.
- ☐ 8. Report results to instructor.
- ☐ 9. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

811

Objective 31

Job Sheet 8—Slow Charge a Battery

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Prepared vehicle for procedure properly	______
• Prepared battery for procedure properly	______
• Determined correct charge rate and time for specific battery	______
• Followed charger manufacturer's instructions for preparing charger for charge and for connecting charger leads to battery	______
• Adjusted charging rate and time properly	______
• Checked battery for full charge correctly	______
• Followed charger manufacturer's instructions for disconnecting charger from battery	______
• Interpreted test results correctly	______
• Selected correct replacement battery as necessary	______
• Followed correct procedure for replacing battery if necessary	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Battery and manufacturer's specifications
- Battery charger and manufacturer's operating instructions
- Appropriate service manual
- Fender covers
- Eye protection
- Rubber gloves
- Rubber apron
- Damp cloths or paper towels
- Thermometer
- Flashlight
- Pencil and paper

Procedure

Slow-charging a conventional (non-sealed) battery

☐ 1. Put on eye protection, rubber gloves, and rubber apron.

☐ 2. If battery is in vehicle, place fender covers over fenders.

☐ 3. If battery is outside vehicle, place battery on an insulated surface—rubber, plastic, or wood—**never** metal or concrete.

☐ 4. Check battery temperature.

  ☐ a. Remove battery filler caps.

  ☐ b. Look down into filler holes over battery cells, using flashlight beam if necessary in poorly lit area, and determine condition of battery electrolyte.

  ☐ c. If electrolyte appears to be frozen or if ice crystals are visible in electrolyte, allow battery to thaw fully before continuing procedure.

☐ 5. Cover battery filler holes with damp cloth or damp paper towel.

☐ 6. Refer to appropriate service manual or battery-manufacturer's specifications to determine charge rate and time for specific battery.

☐ 7. Record charge rate and time.

☐ 8. Prepare battery for charge.

  ☐ a. If battery is in vehicle, disconnect battery cables from terminals.

> Caution: Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode. Therefore, it is very important that you always follow this sequence.

- Disconnect grounded-terminal cable clamp.
- Disconnect insulated-terminal cable clamp.

  ☐ b. If charging battery with side-mounted terminals, insert post adapters to provide a good connection for charger.

☐ 9. Follow charger manufacturer's instructions for preparing charger for charge and for connecting charger leads to battery-terminal posts or adapters.

> Caution: Connecting charger leads to battery-terminal posts or adapters in any other than the recommended sequence can cause the battery to explode.

☐ 10. Turn on charger; adjust charging rate and time.

☐ 11. Charge battery for 15 minutes.

☐ 12. Check appearance of battery and test electrolyte temperature.

  ☐ a. Check battery filler holes for possible spewing of electrolyte.

  ☐ b. Insert thermometer into battery cell and take electrolyte-temperature reading.

  ☐ c. If electrolyte temperature exceeds 125 degrees F, and/or electrolyte spewing has occurred, reduce charging rate and continue to recheck every 15 minutes until charging rate is adjusted to meet requirements in step d.

  ☐ d. If electrolyte temperature is below 125 degrees F and there is no spewing of electrolyte, continue charging until allotted time has passed.

☐ 13. After allotted charge time has passed, check battery filler holes for charged appearance. Battery should be gassing freely.

☐ 14. Follow charger manufacturer's instructions for disconnecting charger from battery.

> Caution: Disconnecting charger leads from the battery in any other than the recommended sequence can cause the battery to explode.

☐ 15. Perform three battery state-of-charge tests (Job Sheet 6) at intervals of one hour; record each reading.

☐ 16. Interpret state-of-charge test results.

  ☐ a. Full-charge specific-gravity reading should be within a range of from 1.260 to 1.280. If readings remain within this range and do not drop during testing period, clean battery and return to service.

- ☐ b. If specific-gravity readings drop during testing period, battery must be replaced.

☐ 17. Clean work area and return equipment and materials to proper storage.

Procedure

Slow-charging a sealed battery

☐ 1. Put on eye protection, rubber gloves, and rubber apron.

☐ 2. If battery is in vehicle, place fender covers over fenders.

☐ 3. If battery is outside vehicle, place battery on an insulated surface—rubber, plastic, or wood—**never** metal or concrete.

☐ 4. Check battery temperature.

- ☐ a. Determine temperature that battery was exposed to during hours before testing.
- ☐ b. If battery was exposed to subfreezing temperatures and battery appears frozen, allow battery to thaw fully before continuing procedure.

☐ 5. Test battery state of charge.

- ☐ a. Perform battery state-of-charge check. (Job Sheet 7)
- ☐ b. Record state-of-charge check results.
- ☐ c. If hydrometer appears clear or light yellow, do not proceed with slow-charging procedure; replace battery.
- ☐ d. Proceed with slow-charge only if red dot appears in built-in hydrometer.

☐ 6. Refer to appropriate service manual or battery manufacturer's specifications to determine charge rate and time for specific battery.

☐ 7. Record charge rate and time.

☐ 8. Prepare battery for charge.

- ☐ a. If battery is in vehicle, disconnect battery cables from terminals.

> Caution: Disconnecting the battery cables in any other than the following sequence can cause the battery to explode.

- ☐ • Disconnect grounded-terminal cable clamp.
- ☐ • Disconnect insulated-terminal cable clamp.

☐ b. If charging battery with side-mounted terminals, insert post adapters to provide a good connection for charger.

☐ 9. Follow charger manufacturer's instructions for preparing charger for charge and for connecting charger leads to battery-terminal posts or adapters.

> Caution: Connecting charger leads to battery terminal posts or adapters in any other than the recommended sequence can cause the battery to explode.

☐ 10. Turn on charger; adjust charging rate and time.

☐ 11. Charge battery for 15 minutes.

☐ 12. Check appearance of battery.

☐ a. Check battery vent holes for possible spewing of electrolyte.

☐ b. Put a light behind battery and look through plastic battery case to check for bubbling of electrolyte.

☐ c. If electrolyte spewing occurs through vent holes or if battery electrolyte appears to be bubbling, reduce charging rate and continue to recheck until charging rate is adjusted to meet requirements in step d.

☐ d. If there is no spewing or bubbling of electrolyte, continue charging.

☐ 13. If battery is outside vehicle, shake or tilt battery at hourly intervals during charging to mix electrolyte.

☐ 14. Check battery for charge. Battery is sufficiently charged when the green dot is visible in sight glass in built-in hydrometer.

☐ 15. If green dot does **not** appear after allotted charging time has passed, battery must be replaced.

☐ 16. Follow charger manufacturer's instructions for disconnecting charger from battery.

> Caution: Disconnecting charger leads from the battery in any other than the recommended sequence can cause the battery to explode.

☐ 17. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

817

Objective 32

Job Sheet 9—Perform a Battery Load Test

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Prepared vehicle for test properly	______
• Inspected and prepared battery for procedure properly	______
• Followed volt-amp-tester manufacturer's instructions for preparing load tester and connecting it to the battery	______
• Followed correct procedure for performing load test	______
• Recorded correct reading	______
• Followed manufacturer's instructions for disconnecting tester from battery	______
• Interpreted test results correctly	______
• Selected correct replacement battery as necessary	______
• Followed correct procedure for installing battery	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading   Critical Thinking   Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Battery and battery-manufacturer's specifications
- Volt-amp tester and manufacturer's operating instructions
- Appropriate service manual
- Eye protection
- Rubber gloves
- Rubber apron
- Glass thermometer
- Pencil and paper

Procedure

Load testing a conventional (non-sealed) battery

☐ 1. Put on eye protection, rubber gloves, and rubber apron.

☐ 2. If battery is inside vehicle, place fender covers over fenders.

☐ 3. If battery is outside vehicle, place battery on an insulated surface—rubber, plastic, or wood—**never** metal or concrete.

- ☐ 4. Perform visual inspection of battery; clean battery if necessary.
- ☐ 5. Test battery temperature.
  - ☐ a. Remove a battery filler cap.
  - ☐ b. Insert thermometer into electrolyte in battery cell.
  - ☐ c. Record electrolyte-temperature reading.
  - ☐ d. If electrolyte temperature is less than 60 degrees F, allow temperature to rise and retest until temperature reads at least 60 degrees.
  - ☐ e. Leave thermometer in electrolyte.
- ☐ 6. Test battery state of charge.
  - ☐ a. Perform battery state-of-charge test. (Job Sheet 6)
  - ☐ b. Record state-of-charge test results and compare test results to range specified by battery manufacturer or appropriate service manual.
  - ☐ c. If state of charge is not within range specified (normally 1.200 specific gravity at 80 degrees F), battery must be slow-charged (Job Sheet 8) and then retested.
  - ☐ d. If after charge the battery state of charge is still **not** within range specified, battery must be replaced.
  - ☐ e. Proceed with load test **only** if battery is within range specified.
- ☐ 7. Prepare battery for load test.
  - ☐ a. If battery is in vehicle, disconnect battery cables from terminals.

    Caution: Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gas and cause the battery to explode.

    - ☐ • Disconnect grounded-terminal cable clamp.
    - ☐ • Disconnect insulated-terminal cable clamp.
  - ☐ b. If testing battery with side-mounted terminals, insert post adapters to provide a good connection for volt-amp-tester leads.

☐ 8. Follow volt-amp-tester manufacturer's instructions for preparing tester for load test and for connecting tester leads to battery-terminal posts or adapters.

> Caution: Connecting tester leads to battery in any other than the sequence recommended by the tester manufacturer can cause the battery to explode.

☐ 9. Refer to appropriate service manual or battery-manufacturer's specifications to determine correct load to place on specific battery being tested.

Note: Some manufacturers provide specific load rates for their batteries; other manufacturers recommend that the load equal three times the ampere-hour rating or one-half the cold-cranking rating.

☐ 10. Perform load test.

  ☐ a. Remove surface charge from battery. Turn load-control knob until specified load has been placed on battery for 15 seconds, then immediately turn control knob to OFF position.

> Caution: Do not apply the load to the battery for more than 15 seconds. You will overheat the resistance unit in the tester.

  ☐ b. Wait 15 seconds and then turn load-control knob until specified load has been placed on battery for 15 seconds. Quickly note voltage indicated on voltmeter, and immediately turn control knob to OFF position.

> Caution: Do not apply the load to the battery for more than 15 seconds.

☐ 11. Record voltmeter reading.

☐ 12. Record electrolyte temperature, and remove thermometer from battery.

☐ 13. Follow volt-amp-tester manufacturer's instructions for disconnecting tester from battery.

> Caution: Disconnecting the tester leads from the battery in any other than the sequence recommended by the tester manufacturer can cause the battery to explode.

☐ 14. Interpret load-test results.

  ☐ a. Compare voltage and temperature readings to appropriate service manual or battery manufacturer's specifications.

  Note: Most specifications will indicate that a battery is good when it will maintain a voltage of at least 9.6 volts while the specified load is applied when the electrolyte temperature is at 70 degrees F or above, but electrolyte temperature will affect the indicated voltage. Use the specifications to determine the minimum voltage allowable for temperatures lower than 70 degrees.

  ☐ b. If voltage reading is below the minimum specified, replace battery.

  ☐ c. If voltage reading is the same or exceeds the minimum specified, clean and slow-charge battery (Job Sheet 7) before returning it to service.

☐ 15. Clean work area and return equipment and materials to proper storage.

Procedure

Load testing a sealed battery

☐ 1. Put on eye protection, rubber gloves, and rubber apron.

☐ 2. If battery is inside vehicle, place fender covers over fenders.

☐ 3. If battery is outside vehicle, place battery on an insulated surface—rubber, plastic, or wood—**never** metal or concrete.

☐ 4. Perform visual inspection of battery; clean battery if necessary.

☐ 5. Estimate battery temperature.

  ☐ a. Determine temperature that battery was exposed to during the preceding few hours before testing.

  ☐ b. Estimate battery temperature by touching battery.

  ☐ c. Record estimated battery temperature.

☐ 6. Test battery state of charge.

  ☐ a. Perform battery state-of-charge check. (Job Sheet 7)

  ☐ b. Record state-of-charge check results.

- ☐ c. If red dot appears in built-in hydrometer, slow-charge battery (Job Sheet 8) until green dot is visible in hydrometer.
- ☐ d. If hydrometer appears clear or light yellow, replace battery.
- ☐ e. Proceed with load test only if green dot is visible in hydrometer.

☐ 7. Refer to appropriate service manual or battery manufacturer's specifications to determine correct load to be placed on battery at temperature estimated in step 5.

☐ 8. Prepare battery for load test.

- ☐ a. If battery is in vehicle, disconnect battery cables from terminals.

  > Caution: Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

  - ☐ • Disconnect grounded-terminal cable clamp.
  - ☐ • Disconnect insulated-terminal cable clamp.

- ☐ b. If testing battery with side-mounted terminals, insert post adapters to provide a good connection for volt-amp-tester leads.

☐ 9. Follow volt-amp-tester manufacturer's instructions for preparing tester for load test and for connecting tester leads to battery-terminal posts or adapters.

> Caution: Connecting tester leads to battery in any other than the sequence recommended by tester manufacturer can cause the battery to explode.

☐ 10. Perform load test.

- ☐ a. Remove surface charge from battery. Turn load-control knob until specified load has been placed on battery for 15 seconds, then immediately turn control knob to OFF position.

  > Caution: Do not apply the load to the battery for more than 15 seconds. You will overheat the resistance unit in the tester.

- ☐ b. Wait 15 seconds and turn load-control knob until specified load has been placed on battery for 15 seconds. Quickly note voltage indicated on voltmeter, and immediately turn control knob to OFF position.

Caution: Do not apply the load to the battery for more than 15 seconds.

☐ 11. Record voltmeter reading.

☐ 12. Follow manufacturer's instructions for disconnecting tester from battery.

Caution: Disconnecting tester from the battery in any other than the sequence recommended by the tester manufacturer can cause the battery to explode.

☐ 13. Interpret load-test results.

- ☐ a. Compare voltage and temperature readings to battery specifications.
- ☐ b. If readings are below the minimum specified, replace battery.
- ☐ c. If readings are the same or exceed the minimum specified, clean and slow-charge battery (Job Sheet 8) before returning it to service.

☐ 14. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

823

Objective 33

Job Sheet 10—Perform a High-Rate Battery Charge Test

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Prepared vehicle for test properly	______
• Inspected and prepared battery for procedure properly	______
• Followed charger manufacturer's instructions for preparing charger and connecting leads to battery	______
• Hooked voltmeter leads to charger cable clamps correctly	______
• Followed correct procedure for performing three-minute charge test	______
• Recorded correct voltmeter reading	______
• Interpreted test results correctly	______
• Selected correct replacement battery as necessary	______
• Followed correct procedure for installing battery	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Critical Thinking Technology

Introduction

A high-rate battery charge test is a quick test used to determine whether a conventional battery is simply discharged or really worn out (the battery has shorted out, the plates have been ruined, etc.)

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Battery and battery manufacturer's specifications
- Adjustable, fast-rate charger and manufacturer's operating instructions
- Voltmeter
- Appropriate service manual
- Eye protection
- Rubber gloves
- Rubber apron
- Glass thermometer
- Pencil and paper

Job Sheet 10

Procedure

Charge-testing a conventional battery

☐ 1. Put on eye protection, rubber gloves, and rubber apron.

☐ 2. If battery is in vehicle, place fender covers over vehicle fenders.

☐ 3. If battery is in vehicle, disconnect battery cables from terminals.

> Caution: Because of the high charging rates used in this test, the battery must be disconnected from the vehicle's electrical system to prevent surges that could cause severe damage to the system.

> Caution: Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode. Therefore, it is very important that you always follow this sequence.

  ☐ a. Disconnect grounded-terminal cable clamp.

  ☐ b. Disconnect insulated-terminal cable clamp.

☐ 4. Remove battery from vehicle and place battery on insulated surface—rubber, plastic, or wood—**never** metal or concrete.

> Caution: Battery should be removed from the vehicle to prevent extensive damage to vehicle should battery explode during procedure.

☐ 5. If testing battery with side-mounted terminals, insert post adapters to provide a good connection for charger.

☐ 6. Check battery temperature.

  ☐ a. Remove battery filler caps.

  ☐ b. Look down into filter holes over battery cells, using flashlight beam if necessary in poorly lit area, and determine condition of battery electrolyte.

  ☐ c. If electrolyte appears to be frozen or if ice crystals are visible in electrolyte, allow battery to thaw fully before continuing procedure.

☐ 7. Refer to appropriate service manual or battery-manufacturer's specifications to determine charge rate for specific battery.

☐ 8. Record charge rate.

☐ 9. Follow charger manufacturer's instructions for preparing charger for test and for connecting charger leads to battery-terminal posts or adapters.

> Caution: Connecting charger leads to battery-terminal posts or adapters in any other than the recommended sequence can cause the battery to explode.

☐ 10. Hook voltmeter leads to charger cable clamps.

☐ 11. Turn on charger and adjust charging rate.

☐ 12. Charge battery for three minutes.

☐ 13. With charger still charging, quickly take voltmeter reading.

Note: The charger must be charging the battery when the voltmeter reading is taken.

☐ 14. Turn charger off.

☐ 15. Record voltmeter reading.

☐ 16. Interpret charge-test results.

  ☐ a. If voltmeter reading is less than 15.5 volts, the battery will probably accept a charge. Clean and slow-charge battery before returning battery to service.

  ☐ b. If reading is above 15.5 volts, the battery will not accept a charge and must be replaced.

☐ 17. Disconnect voltmeter and follow charger manufacturer's instructions for disconnecting charger from battery.

> Caution: Disconnecting charger leads from the battery in any other than the recommended sequence can cause the battery to explode.

☐ 18. Clean work area and return equipment and materials to proper storage.

Procedure

Charge-testing a sealed battery

☐ 1. Put on eye protection, rubber gloves, and rubber apron.

☐ 2. If battery is in vehicle, place fender covers over vehicle fenders.

☐ 3. If battery is in vehicle, disconnect battery cables from terminals.

> Caution: Because of the high charging rate used in this test, the battery must be disconnected from vehicle's electrical system to prevent surges that could cause severe damage to the system.

> Caution: Disconnecting the battery cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode. Therefore, it is very important that you always follow this sequence.

- ☐ a. Disconnect grounded-terminal cable clamp.
- ☐ b. Disconnect insulated-terminal cable clamp.

☐ 4. Remove battery from vehicle and place on insulated surface—rubber, plastic, or wood—**never** metal or concrete.

> Caution: Battery should be removed from the vehicle to prevent extensive damage to vehicle should battery explode during procedure.

☐ 5. If testing battery with side-mounted terminals, insert post adapters to provide a good connection for charger.

☐ 6. Check battery temperature.

- ☐ a. Determine temperature that battery was exposed to during hours before testing.
- ☐ b. If battery was exposed to subfreezing temperatures and battery appears frozen, allow battery to thaw fully before continuing procedure.

☐ 7. Test battery state of charge.

- ☐ a. Perform state-of-charge check. (Job Sheet 7)
- ☐ b. Record state-of-charge check results.
- ☐ c. If hydrometer appears clear or light yellow, do not proceed with testing procedure; replace battery.
- ☐ d. Proceed with test only if red dot appears in built-in hydrometer.

☐ 8. Refer to appropriate service manual or battery-manufacturer's specifications to determine charge rate for specific battery.

☐ 9. Record charge rate.

☐ 10. Follow charger manufacturer's instructions for preparing charger for test and for connecting charger leads to battery-terminal posts or adapters.

> Caution: Connecting charger leads to battery-terminal posts or adapters in any other than the sequence recommended by the charger manufacturer can cause the battery to explode.

☐ 11. Hook voltmeter leads to charger cable clamps.

☐ 12. Turn on charger and adjust charging rate, according to manufacturer's recommendations.

☐ 13. With charger still charging, quickly take voltmeter reading.

Note: The charger must be charging the battery when the voltmeter reading is taken.

☐ 14. Turn charger off.

☐ 15. Record voltmeter reading.

☐ 16. Interpret charge-test results according to manufacturer's recommendations.

  ☐ a. If battery can be charged, charge and return to service.

  ☐ b. If battery cannot be charged, remove from service and replace.

☐ 17. Disconnect voltmeter and follow charger manufacturer's instructions for disconnecting charger from battery.

> Caution: Disconnecting charger leads from the battery in any other than the recommended sequence can cause the battery to explode.

☐ 18. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ____________________

____

____

Objective 34

Job Sheet 11—Emergency Jump-Start a Vehicle

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	_____
• Prepared vehicle(s) and batteries for procedure properly	_____
• Followed correct procedure for connecting jumper cables to batteries	_____
• Followed correct procedure for jump start	_____
• Followed correct procedure for disconnecting jumper cables from batteries	_____
• Cleaned work area and properly stored equipment and materials	_____

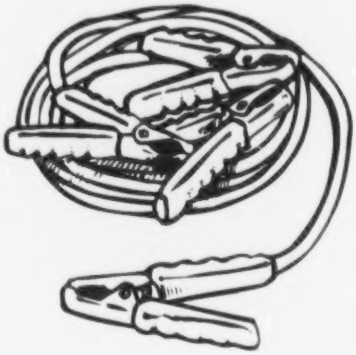
Basic Skills

Reading Critical Thinking Technology

Introduction

Jump-starting is a procedure used in an emergency to start a vehicle with a discharged battery. During the procedure, jumper cables, heavy electrical cables with terminal clamps at each end (see Figure 1), are connected between the discharged battery and a good battery, called the booster battery. The booster battery may be a separate battery brought to the vehicle with the discharged battery, or it may be a battery in another vehicle.

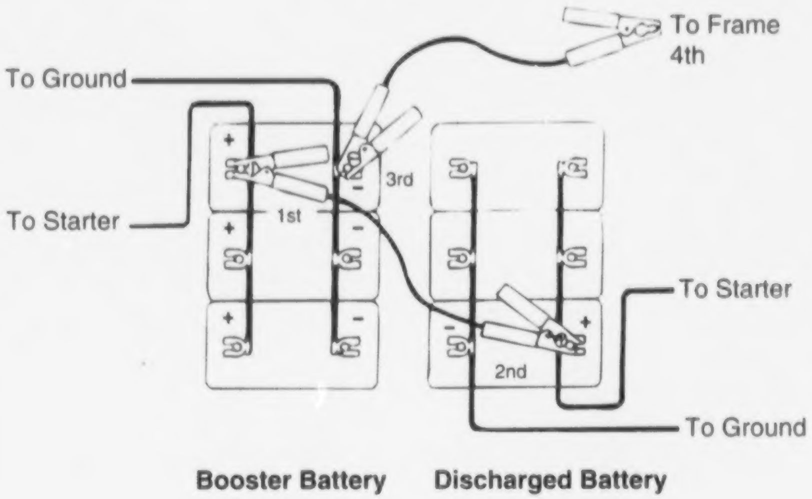
Figure 1



- Always begin the procedure by connecting one jumper-cable terminal clamp to the positive terminal of the booster battery (identified by a red color, "P", or "+" on the battery case or terminal) and the other end of the same cable to the positive terminal of the discharged battery. See Figure 2.
- Then connect one end of the remaining jumper cable to the negative terminal of the booster battery (identified by a black color, "N", or "–" on the battery case or terminal) and the other end to a good ground—such as the engine block, frame, alternator bracket, or air-conditioner compressor bracket—that is at least 18 inches away from the discharged battery. See Figure 2.

Never connect a booster battery directly to a discharged battery, and never try to ground the cable to any part of the vehicle's fuel system.

Figure 2—Correct method of attaching jumper cables to a 12-volt system



Reproduced by permission. Heavy Duty Truck Systems by Norman and Scharff. Delmar Publishers, Albany, New York, Copyright 1991.

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Vehicle with discharged battery
- Booster battery
- Jumper cables
- Paper towels or cloth
- Eye protection
- Protective clothing
- Container of water

Procedure

Jump-starting a vehicle with a conventional battery

☐ 1. If using the booster battery in another vehicle, position vehicles so that they do **not** touch each other.

☐ 2. Set parking brake; place vehicle with automatic transmission in PARK and vehicle with manual transmission in NEUTRAL.

☐ 3. Turn off any electrical load in vehicle with discharged battery.

Note: Turn off lights and heater, remove the key from the ignition, and close vehicle doors.

☐ 4. Put on eye protection and protective clothing.

☐ 5. Place fender covers over vehicle fenders.

☐ 6. Prepare discharged battery for jump-starting procedure.

  ☐ a. If ambient (air) temperature is below freezing, check condition of discharged battery's electrolyte.

Caution: At temperatures below freezing, the electrolyte in a discharged battery may freeze. Do not attempt to jump-start a vehicle with a frozen battery. A frozen battery may rupture or explode if jump-start is attempted.

    ☐ • Remove battery filler caps.

    ☐ • Look down into battery cells, using flashlight beam if necessary in poorly lit area, and determine condition of battery electrolyte.

    ☐ • If electrolyte appears to be frozen or if ice crystals are visible in electrolyte, do not attempt jump-start. Remove battery from vehicle, and take to a warm environment to allow battery to thaw fully.

    ☐ • Proceed with jump-start only if battery is completely thawed.

  ☐ b. Check electrolyte level.

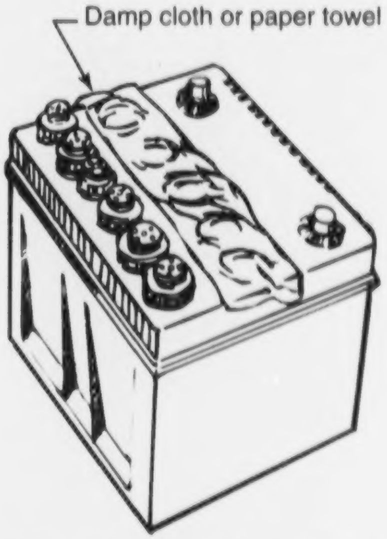
    ☐ • Look down into battery cells, using flashlight beam if necessary in poorly lit area, and determine electrolyte level.

    ☐ • If electrolyte level is low, fill with water until electrolyte level is above tops of plates.

☐ c. Cover filler holes with damp cloth or paper towel.

Note: Covering the filler holes with a cloth or paper towel will prevent the electrolyte from spewing from the filler holes during the jump-starting procedure.

Figure 3



Adapted with permission of Chrysler Motor Corporation.

☐ 7. Connect jumper cables to batteries.

> Caution: Connecting the jumper cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

☐ a. Connect one jumper-cable terminal clamp to positive terminal of booster battery.

☐ b. Connect terminal clamp at other end of same jumper cable to positive terminal of discharged battery.

☐ c. Connect one terminal clamp of remaining jumper cable to negative terminal of booster battery.

- ☐ d. Connect remaining terminal clamp of same cable to a good ground at least 18 inches away from discharged battery.

> Caution: Never connect a booster battery directly to the discharged battery. Never ground cable to any part of the vehicle's fuel system.

☐ 8. Place key in ignition of vehicle with discharged battery and attempt to start engine.

> Caution: If booster battery is in another vehicle, battery should be disconnected from that vehicle's electrical system. Never leave booster battery connected to electrical system and never start the engine of that vehicle. Extensive damage would result to the electrical systems of both vehicles.

☐ 9. Disconnect jumper cables.

Note: Disconnect jumper cables whether or not the vehicle starts on the first try. Further attempts at jump-starting the vehicle will only run down the booster battery.

> Caution: Disconnecting the jumper cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

- ☐ a. Disconnect jumper-cable terminal clamp from ground on engine.
- ☐ b. Disconnect jumper-cable terminal clamp from negative terminal of booster battery.
- ☐ c. Disconnect jumper-cable terminal clamp from positive terminal of discharged battery.
- ☐ d. Disconnect jumper-cable terminal clamp from positive terminal of booster battery.

☐ 10. Remove damp cloth or paper towel covering filler holes on discharged battery.

☐ 11. Install battery filler caps.

☐ 12. Clean work area and return equipment and materials to proper storage.

Job Sheet 11

Procedure

Jump-starting a vehicle with a sealed battery

☐ 1. If using a booster battery in another vehicle, position vehicles so that they do **not** touch each other.

☐ 2. Set parking brake; place vehicle with automatic transmission in PARK and vehicle with manual transmission in NEUTRAL.

☐ 3. Turn off any electrical load in vehicle with discharged battery.

Note: Turn off lights and heater, remove the key from the ignition, and close vehicle doors.

☐ 4. Put on eye protection and protective clothing.

☐ 5. Place fender covers over vehicle fenders.

☐ 6. Prepare discharged battery for jump-starting procedure.

  ☐ a. Determine temperature that battery was exposed to during preceding hours.

  ☐ b. If battery was exposed to subfreezing temperatures and battery appears frozen, do not attempt jump-start. Remove battery from vehicle, and take to a warm environment to allow battery to thaw fully.

> Caution: At temperatures below freezing, the electrolyte in a discharged battery may freeze. Do not attempt to jump-start a vehicle with a frozen battery. A frozen battery may rupture or explode if jump-start is attempted.

  ☐ c. Check battery state of charge. (Job Sheet 7)

  ☐ d. If hydrometer appears clear or light yellow, do not proceed with jump-starting procedure; replace battery.

  ☐ e. Proceed with jump-start procedure only if red dot appears in built-in hydrometer and battery is completely thawed.

☐ 7. Connect jumper cables to batteries.

> Caution: Connecting jumper cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

834

☐ a. Connect one jumper-cable terminal clamp to positive terminal of booster battery.

☐ b. Connect terminal clamp at other end of same jumper cable to positive terminal of discharged battery.

☐ c. Connect one terminal clamp of remaining jumper cable to negative terminal of booster battery.

☐ d. Connect remaining terminal clamp of same cable to a good ground at least 18 inches away from discharged battery.

> Caution: Never connect a booster battery directly to the discharged battery. Never ground cable to any part of the vehicle's fuel system.

☐ 8. Place key in ignition of vehicle with discharged battery and attempt to start engine.

> Caution: If booster battery is in another vehicle, battery should be disconnected from that vehicle's electrical system. Never leave booster battery connected to electrical system and never start the engine of that vehicle. Extensive damage would result to the electrical systems of both vehicles.

☐ 9. Disconnect jumper cables.

Note: Disconnect jumper cables whether or not the vehicle starts on the first try. Further attempts at jump-starting the vehicle will only run down the booster battery.

> Caution: Disconnecting jumper cables in any other than the following sequence can cause a spark that can ignite battery gases and cause the battery to explode.

☐ a. Disconnect jumper-cable terminal clamp from ground on engine.

☐ b. Disconnect jumper-cable terminal clamp from negative terminal of booster battery.

☐ c. Disconnect jumper-cable terminal clamp from positive terminal of discharged battery.

☐ d. Disconnect jumper-cable terminal clamp from positive terminal of booster battery.

☐ 10. Clean work area and return equipment and materials to proper storage.

Evaluator's Comments: ____

____

____

836

Basic Hydraulic Principles

Unit Contents

Student Components

Student Page

Objective Sheet 2C-3

Information Sheet 2C-5

Assignment Sheet

1—Draw a Block Diagram of a Simple Hydraulic System 2C-15

Job Sheets

1—Perform General Maintenance Procedures on a Hydraulic System 2C-17

2—Change Hydraulic Fluid and Filter 2C-19

837

Objective Sheet

Unit Objective

After completing this unit, the student should be able to perform basic maintenance on hydraulic systems. The student should demonstrate these competencies by completing the assignment sheet and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic hydraulic principles with their definitions.
2. Name systems that use hydraulics in diesel technology.
3. Explain advantages and disadvantages of hydraulic systems.
4. Match components of a basic hydraulic system with their functions.
5. Arrange in order the steps in the basic operation of a hydraulic system.
6. Complete statements concerning basic hydraulic principles.
7. Calculate pressure.
8. Select functions of hydraulic fluid.
9. List two types of reservoirs.
10. Identify parts of a reservoir.
11. List causes of damage to hydraulic systems.
12. Select common problems in hydraulic systems.
13. Name reasons for performing preventive maintenance on hydraulic systems.
14. List steps for general maintenance of a hydraulic system.
15. List steps in keeping hydraulic systems clean.
16. Discuss safety hazards and safety practices when working with hydraulic systems.
17. Draw a block diagram of a simple hydraulic system. (Assignment Sheet 1)
18. Perform general maintenance procedures on a hydraulic system. (Job Sheet 1)
19. Change hydraulic fluid and filter. (Job Sheet 2)

Information Sheet

Objective 1

Terms and definitions

a. **Actuator**—Device that converts hydraulic energy into mechanical energy

Examples: Cylinder, motor

b. **Cavitation**—Formation of air bubbles in the inlet of a pump because the inlet does not completely fill with fluid

c. **Fluid**—Substance (liquid or gas) that has no shape of its own and tends to flow

d. **Hydraulics**—Study of liquids in motion and at rest

e. **Line**—Tube, pipe, or hose for conducting a fluid

f. **Liquid**—Type of fluid that is relatively incompressible

g. **Pressure**—Force exerted over a surface divided by its area

h. **Pump**—Device that forces the flow of hydraulic fluid; converts mechanical energy into hydraulic energy

i. **Reservoir**—Container for keeping a supply of working fluid in a hydraulic system

j. **Valve**—Device that controls either pressure of fluid, direction of fluid flow, or rate of flow

Objective 2

Systems that use hydraulics in diesel technology

Note: Many diesel systems use hydraulic power. The following examples represent some of the more common applications on different types of equipment.

a. Lifting systems and equipment

b. Auxiliary controls and actuators

c. Brakes

d. Hitch controls

e. Power steering

f. Retarders or engine brakes

Objective 3

Advantages and disadvantages of hydraulic systems

a. **Advantages**

- Flexibility—Allows flexible transfer of large forces
- Multiplication of force—Small forces can be used to control large forces
- Simplicity—Has fewer moving parts and points of wear than a mechanical system; can lubricate itself
- Compactness—Hydraulic motors are more compact than electrical motors of equal horsepower
- Economy—Low installation cost; low operating cost
- Safety—Hydraulic systems have fewer moving parts and present fewer potential hazards than mechanical systems with gears and chains

b. **Disadvantages**

- Safety—High pressure is potentially dangerous
- Cleanliness—System must be kept very clean to prevent excessive wear of the components
- Leaks—With almost any system under pressure, leaks are inevitable

Objective 4

Components of a basic hydraulic system and their functions

a. **Reservoir (tank)**—Stores the hydraulic fluid; also helps to cool and filter the system

b. **Pump**—Forces fluid under pressure to and through system

c. **Lines**—Carry the fluid

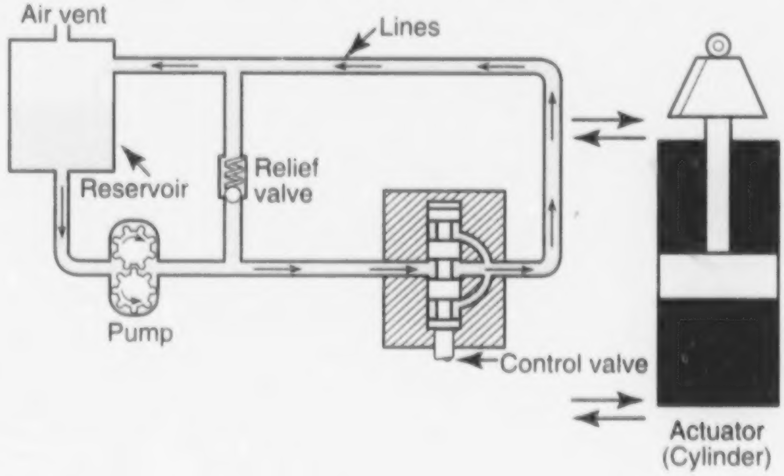
d. **Filter**—Cleans the fluid

e. **Valves**—Control the pressure, direction, or rate of fluid flow; several types including bypass, relief, control, and check

f. **Actuators**—Perform desired outcome—movement; convert hydraulic energy (pressure) into mechanical energy (motion); may be cylinders or motors

g. **Cooler**—Lowers or maintains low temperature of hydraulic fluid; optional component

Figure 1—Components of a basic hydraulic system


Air vent
Lines
Reservoir
Relief valve
Pump
Control valve
Actuator (Cylinder)

Objective 5

Basic operation of a hydraulic system

a. Pump draws the fluid from the reservoir.

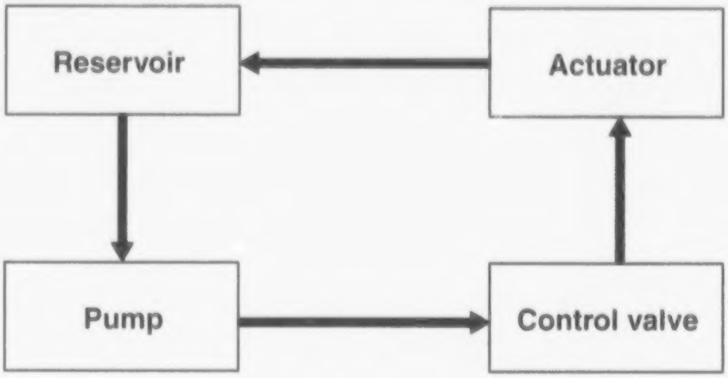
b. Pump forces fluid through the lines to the chambers of a control valve.

c. Control valve directs fluid to the actuator.

d. Actuator uses hydraulic pressure to cause movement and to perform work.

e. Fluid is returned to reservoir.

Figure 2—Block diagram of simple hydraulic system

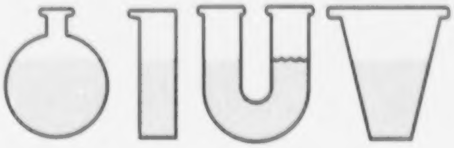

Reservoir
Actuator
Pump
Control valve

Objective 6

Basic hydraulic principles

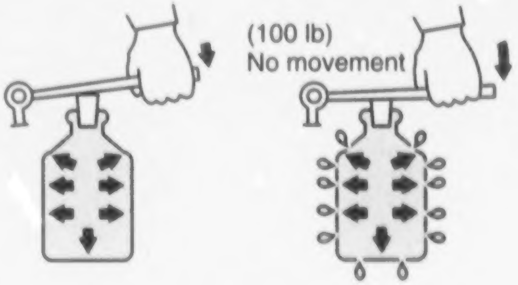
a. Liquids have no shape of their own.

Figure 3



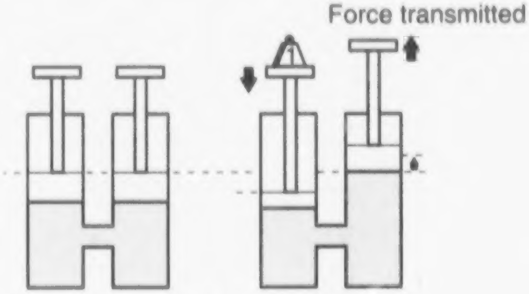
b. Liquids cannot be compressed.

Figure 4


(100 lb)
No movement

c. Liquids can be used to transmit force.

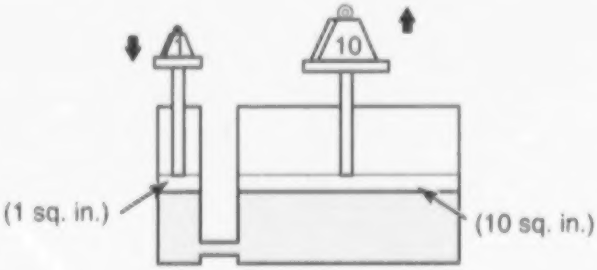
Figure 5


Force transmitted

542

d. Liquids can be used to multiply force.

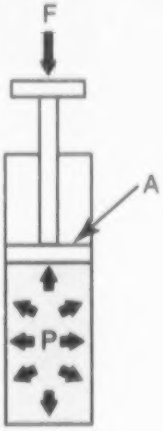
Figure 6



Courtesy of Deere and Co.

e. Pressure set up in a confined liquid acts equally in all directions. This is Pascal's law.

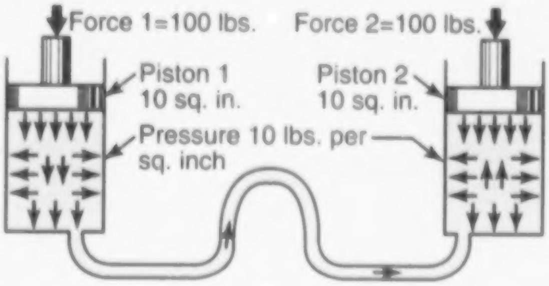
Figure 7—Pascal's Law



f. Applications of these principles

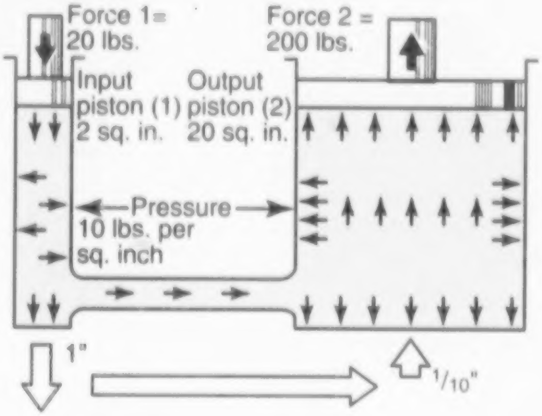
- If the input and output pistons have equal areas and equal pressures, the output force will be equal to the input force.

Figure 8—Equal area + Equal pressure = Equal force


Force 1=100 lbs.
Force 2=100 lbs.
Piston 1
10 sq. in.
Piston 2
10 sq. in.
Pressure 10 lbs. per
sq. inch

- If the input and output pistons have unequal areas and equal pressures, the output and input forces will be unequal.

Figure 9—Unequal area + Equal pressure = Unequal force


Force 1=
20 lbs.
Force 2 =
200 lbs.
Input
piston (1)
2 sq. in.
Output
piston (2)
20 sq. in.
Pressure
10 lbs. per
sq. inch
1"
1/10"

844

Objective 7

Calculating pressure

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

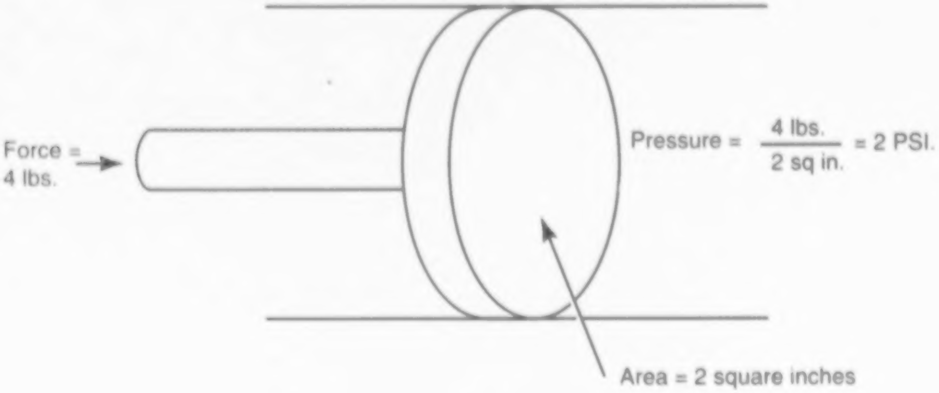
a. Determine force.

b. Determine area of surface to which force is applied.

c. Divide force by area of surface to which force is applied.

Note: Pressure is normally measured in units of pounds per square inch (PSI). Therefore, force should be expressed in pounds, and area should be expressed in square inches.

Figure 10—Example of calculating pressure


Force = 4 lbs.
Pressure = $\frac{4 \text{ lbs.}}{2 \text{ sq in.}}$ = 2 PSI.
Area = 2 square inches

Objective 8

Functions of hydraulic fluids

a. **Power transmission**—Provides a medium for transferring force from one location to another

b. **Lubrication**—Lessens friction on internal surfaces of hydraulic system components in order to reduce wear

c. **Sealing**—Reduces flow through leakage paths

d. **Cooling**—Provides a medium for removing heat generated in the system

Objective 9

Types of reservoirs

a. Vented to atmosphere (typical)

b. Pressurized and sealed (special applications)

Information Sheet

Objective 10

Parts of a reservoir

a. **Filler cap**—Used to open reservoir when additional hydraulic fluid needs to be added

b. **Fluid level gauge**—Indicates amount of fluid in reservoir

c. **Baffle**—Helps separate inlet fluid from outlet fluid and aids in air and dirt separation and cooling

d. **Reservoir outlet**—Exit port for fluid leading from reservoir to pump

e. **Return lines**—Entry port for fluid leading from actuator to reservoir

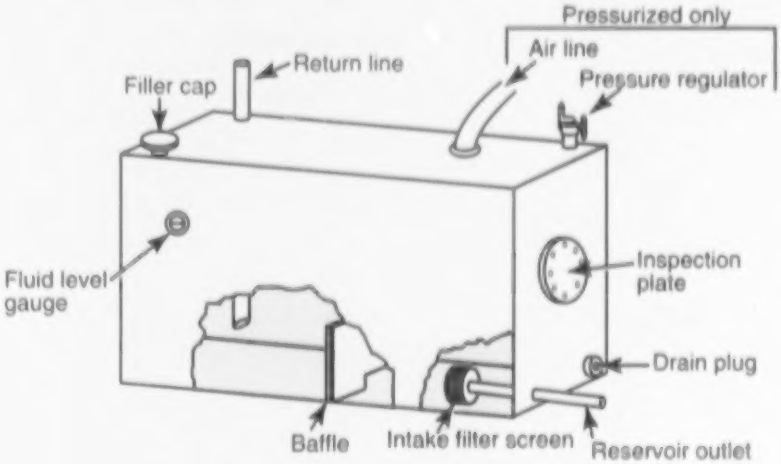
f. **Intake filter screen**—Blocks debris and helps protect the pump

g. **Drain plug**—Opened for removing old fluid from reservoir

Note: Some drain plugs are magnetic to help remove metal particles from fluid.

h. **Inspection plate**—Removed for making visual inspections of reservoir

Figure 11—Parts of a reservoir


Pressurized only
Air line
Pressure regulator
Return line
Filler cap
Fluid level gauge
Inspection plate
Drain plug
Baffle
Intake filter screen
Reservoir outlet

Objective 11

Causes of damage to hydraulic systems

a. Too much speed

b. Too much heat

c. Too much pressure

d. Too much contamination

Objective 12

Common problems in hydraulic systems

a. Not enough oil in the reservoir
b. Clogged or dirty oil filters
c. Loose inlet lines
d. Incorrect oil in the system

Objective 13

Reasons for performing preventive maintenance on hydraulic systems

a. Prolong the life of the system
b. Reduce down time
c. Reduce or eliminate needless failures

Objective 14

Steps for general maintenance of a hydraulic system

a. Check fluid level.
b. Inspect for leaks.
c. Inspect hoses, lines, and drive components for excessive wear.
d. Check for proper system operation.
e. During operation, watch and listen to system to check for:
  - Unusual sounds
  - Abnormal flow through relief valve—Often indicated by a high-pitched sound
  - Cavitation—Often indicated by a low-pitched sound

f. Change filter and fluid according to manufacturer's recommendations.

Objective 15

Steps in keeping hydraulic systems clean

a. Keep the oil clean.
b. Keep the system clean.
c. Keep the work area clean.
d. Use oil recommended by the manufacturer when changing or adding oil.

Objective 16

Safety hazards and safety practices when working with hydraulic systems

a. **Safety hazards**

- Components subjected to excessive pressure may explode.
- Accidental release of trapped oil in hydraulic circuits supporting booms or attachments may cause these components to malfunction or fall suddenly.
- Hot oil from leaks, disconnected lines, or reservoir drains can cause severe burns.
- Pinhole leaks in high-pressure circuits can release potentially dangerous fluids.
- Many hydraulic fluids are extremely flammable.
- Some hydraulic fluids can irritate or burn when they contact the skin or eyes.

b. **Safety practices**

Note: In addition to safety practices required working with all fluids and lubricants outlined in Unit 4-B "Fluids and Lubricants," the following rules are also essential to hydraulic system safety:

- Support booms and lower attachments to ground before working on a hydraulic system.
- Operate all control levers to check to see that hydraulic pressure has been relieved.
- Loosen lines and components in a circuit slowly to relieve trapped pressure.
- Stop equipment and repair leaks immediately.
- Wear safety glasses and a safety helmet as required when working with any system under pressure.

Objective 17

Assignment Sheet 1—Draw a Block Diagram of a Simple Hydraulic System

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Drawing is complete and correct	______
• Drawing is neat and legible	______

Basic Skills

Reading Science Critical Thinking

Directions

Draw a block diagram of a simple hydraulic system, showing a reservoir, pump, valves, lines, and actuator. Designate flow direction by drawing arrows in the lines. Label each part.

Objective 18

Job Sheet 1—Perform General Maintenance Procedures on a Hydraulic System

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Checked fluid level correctly and added fluid as needed	______
• Inspected system thoroughly, and tightened or replaced lines, fittings, and couplings as needed	______
• Checked system	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Clean lint-free shop towel
- Hydraulic fluid as specified by manufacturer

Caution: Follow all shop safety procedures throughout this procedure.

Procedure

☐ 1. Check system to see if it has a vented or pressurized reservoir. If pressurized, relieve pressure at this time using caution.

☐ 2. Clean filter cap and remove.

☐ 3. Visually check fluid level.

Note: Level should be according to manufacturer's specifications.

☐ 4. If the fluid level is low, add clean hydraulic fluid, as specified by the manufacturer, to the reservoir.

☐ 5. Visually inspect the system, and complete the following checklist. Check the appropriate boxes, and briefly describe the condition of the components.

	✓	Condition
a. Check for frayed hoses and protect or cover hoses that are showing signs of wear		
b. Check for damaged lines		
c. Check drive line couplings to ensure they are not excessively worn		
d. Check couplings to ensure they are securely attached to the shafts		

☐ 6. Replace hoses, lines, and couplings that are damaged or excessively worn and report the problem to the instructor.

☐ 7. Check the system for leaks and tighten any fitting that is leaking.

Note: If this does not stop the leak, the fitting may have to be replaced.

☐ 8. Start the system.

☐ 9. Check the operation of all the functions of the system.

☐ 10. Report any improper operation or any part that fails to function properly to the instructor.

☐ 11. With the system operating, listen for unusual sounds such as cavitation or improper operation of the relief valve.

☐ 12. Clean up area and return tools and materials to proper storage, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: ______________________________

____

____

Objective 19

Job Sheet 2—Change Hydraulic Fluid and Filter

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Released system pressure and opened system correctly	______
• Drained fluid and inspected and cleaned reservoir correctly	______
• Removed old filter and cleaned housing correctly	______
• Installed new filter and fluid according to manufacturer's specifications	______
• Bled system and checked properly	______
• Cleaned inlet screen correctly	______
• Cleaned work area and properly stored equipment and materials	______

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Wrench to fit reservoir drain plug
- Wrench for removing filter
- Clean lint-free shop towel
- Hydraulic fluid according to manufacturer's recommendation
- Hydraulic filter

Caution: Follow all shop safety procedures throughout this procedure.

Procedure

☐ 1. Operate levers to release system pressure.

☐ 2. Slowly open reservoir filler cap to relieve pressure on reservoir.

☐ 3. Drain the fluid by removing the drain plug in the reservoir.

☐ 4. Open the inspection plate on the reservoir.

☐ 5. Remove any dirt and foreign material which has settled in the bottom of the reservoir.

☐ 6. Replace the inspection plate and drain plug.

☐ 7. Clean the area around the filter.

☐ 8. Remove the old filter.

☐ 9. Clean the filter housing if it is a cartridge type filter.

☐ 10. Install a new filter and tighten to manufacturer's specifications.

☐ 11. Fill the reservoir with hydraulic fluid.

☐ 12. Bleed system if necessary.

☐ 13. Operate system and check for leaks.

☐ 14. Check fluid level to ensure it is still within specifications.

☐ 15. Remove and clean the inlet screen.

☐ 16. Clean up area and return tools and materials to proper storage.

Evaluator's Comments: ________________________________

____

____

Unit 3-C Basic Welding and Cutting

Unit Contents

Student Components

Student Page

Objective Sheet 3C-3
Information Sheet 3C-5

Student Supplements

1—Covered Electrodes for SMAW of Carbon Steel (per AWS A5.1) 3C-27
2—Recommended Amperages for Electrodes by Type and Diameter (Current Range, A) 3C-29
3—Oxyacetylene Welding Perameters 3C-31
4—Parameters for Oxyfuel Cutting 3C-33

Job Sheets

1—Start, Stop, and Restart a Bead 3C-35
2—Construct a Pad Weld 3C-39
3—Construct a Butt Weld 3C-43
4—Construct a Lap-Joint Fillet Weld in the Flat Position 3C-45
5—Construct a T-Joint Fillet Weld in the Flat Position 3C-47
6—Set up Equipment for Oxyacetylene Welding/Cutting 3C-49
7—Turn On, Light, Adjust, and Shut Down Oxyacetylene Welding Equipment 3C-53
8—Braze Weld a Lap Joint 3C-57
9—Cut Mild Steel at a 90° Angle, Stop, and Restart the Cut 3C-61
10—Cut Round Stock 3C-65

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify weld joints and be able to perform basic welding and cutting tasks. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic welding and cutting with their definitions.
2. Distinguish between correct and incorrect safety precautions to follow when welding.
3. Match welding materials with their descriptions.
4. Complete statements concerning the basic arc welding circuit.
5. Match the parts of the arc welding process with their descriptions.
6. Name types of arc welding machines.
7. Distinguish between true and false statements concerning polarity.
8. Describe effects of raising and lowering welding machine amperes.
9. Match common types of arc welding electrodes with their descriptions.
10. Select common diameter sizes of arc welding electrodes.
11. Interpret meanings of AWS electrode classification numbers.
12. List factors to consider when selecting electrodes.
13. Select purposes of electrode flux.
14. Match types of welds with their descriptions.
15. Identify types of weld joints.
16. Select characteristics of good welds.
17. List reasons for poor welds.
18. Identify the methods of striking an arc.
19. Select characteristics of proper arc length.
20. Identify types of electrode motions.

Objective Sheet

21. Identify positions used in arc welding.
22. Label the parts of an oxyacetylene outfit.
23. Name factors that determine selection of welding tip size.
24. Arrange in order the stages of oxyacetylene torch combustion.
25. Distinguish among types of oxyacetylene flames.
26. Define flashback and backfire.
27. Arrange in order the steps to follow in case of flashback.
28. Select causes of backfire.
29. Discuss advantages and disadvantages of oxyacetylene braze welding.
30. Discuss the importance of having a chemically clean metal surface in braze welding.
31. List methods of removing oxides from a metal surface.
32. Explain reactions of molten bronze at different temperatures.
33. Identify parts of a torch body and cutting attachment.
34. Start, stop, and restart a bead. (Job Sheet 1)
35. Construct a pad weld. (Job Sheet 2)
36. Construct a butt weld. (Job Sheet 3)
37. Construct a lap-joint fillet weld in the flat position. (Job Sheet 4)
38. Construct a T-joint fillet weld in the flat position. (Job Sheet 5)
39. Set up equipment for oxyacetylene welding/cutting. (Job Sheet 6)
40. Turn on, light, adjust, and shut down oxyacetylene welding equipment. (Job Sheet 7)
41. Braze weld a lap joint. (Job Sheet 8)
42. Cut mild steel at a 90° angle, stop, and restart the cut. (Job Sheet 9)
43. Cut round stock. (Job Sheet 10)

Information Sheet

Objective 1

Terms and definitions

a. **Acetylene**—Colorless, gaseous hydrocarbon used in cutting and welding

Note: Other gases are also used in welding.

b. **Alloy**—Substance composed of two or more metals or a metal and a nonmetal fused together

c. **American Welding Society (AWS)**—Association that sets welding standards

d. **Arc welding**—Joining of two or more pieces of metal by fusion process that uses an arc to heat the metal

Note: Arc welding may be referred to as shielded metal-arc welding (SMAW) or stick welding.

e. **Bevel**—Angular cut made on the vertical edge of base metal to allow better weld penetration

f. **Braze welding**—Heating base metal to a dull red and depositing a bead over the seam (joint) with a filler rod, without melting the base metal

g. **Butt joint**—Weld between two metal joints on the same plane

h. **Ductile**—Capable of being drawn or stretched

i. **Filler rod**—Bronze rod with characteristics similar to base metal

j. **Flint lighter**—Striker used to ignite torch

k. **Fusion welding**—Joining pieces of metal by heating adjoining edges to the fusion point and allowing them to flow or run together and then cool

l. **Lead**—Cables leading from ground clamp and holder to machine

m. **Molten**—Liquified by heat

n. **Oxide**—Substance produced when oxygen is combined with another element

o. **Oxidize**—To combine oxygen with another element

p. **Oxyacetylene cutting**—Method of cutting metal using an oxyacetylene torch to preheat the metal

q. **Oxyacetylene welding**—Method of welding using an oxyacetylene torch to bring about fusion

r. **Oxygen**—Element that is normally a colorless, odorless, and tasteless gas; used in combination with other substances in cutting and welding

s. **Pass**—Single longitudinal progression of a welding operation along a joint or weld deposit

t. **Puddle**—Portion of a weld that is molten at the place heat is applied

u. **Purge**—To remove any foreign material from a system or component by flushing with the gas used in that system

v. **Rippled**—Lightly ruffled or covered with small waves

Objective 2

Safety precautions to follow when welding

a. Wear proper protective clothing such as welder's goggles, shield, or helmet; leather vest or apron; long-sleeved shirt with buttoned collar and cuffs; leather gloves; and high-topped shoes or boots.

b. Wear gloves and use locking clamps or pliers to handle hot metal.

c. Make sure that an appropriate fire extinguisher is readily available and in working condition.

d. If you feel dizzy or nauseated or if you have blurred vision, stop cutting and get some fresh air.

e. Do not look at arc or flame or reflection of arc or flame without eye protection.

f. Do not wear goggles, shields, or helmets that are in bad condition.

g. Do not chip slag without wearing safety goggles.

h. Do not strike an arc or light a torch until you have taken all safety precautions.

i. Do not weld around combustible or flammable materials.

Note: Keep gloves, hands, and clothing free of oil and grease.

j. Do not cut or weld on containers that have been used to store combustible materials unless containers have been properly cleaned and purged.

Examples: Containers that have held gases such as nitrogen, carbon dioxide, or argon

k. Be sure that confined areas are properly ventilated.

l. Do not breathe toxic fumes.

Examples: Galvanized metal fumes, some paint fumes

m. Disconnect plug before checking arc welding machine.

n. Do not use arc welding machine with worn or frayed cables.

o. Do not leave arc welding electrode holder on welding table or in direct contact with grounded metal.

p. Dispose of arc welding electrode stubs properly.

q. Do not leave a burning oxyacetylene torch unattended.

r. Secure oxyacetylene cylinders in a safe place to protect valves and regulators and to prevent injuries.

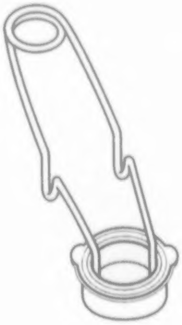
s. Cut or weld at least five feet from cylinders.

t. Always use regulators. Do not use oxygen or acetylene directly from cylinders.

Note: Be sure to use regulators only on cylinders for which they were designed.

u. Use flint lighters, not matches, to light oxyacetylene torch.

Figure 1



v. Use only hoses designated for oxygen and acetylene.

w. Do not use oil on regulators, torches, fittings, or any equipment surface that may come in contact with oxygen.

Caution: Never oil or grease oxygen fittings. Substances will ignite with a violent explosion.

x. Do not use compressed oxygen to clean off clothing.

> Caution: Do not confuse compressed oxygen with compressed air. Oxygen speeds combustion, and oxygen-soaked clothing needs only a spark to burst into flame.

y. Do not breathe compressed oxygen directly from cylinder or hose.

z. Use soapsuds and paintbrush to test oxyacetylene connections for leaks.

aa. Do not use acetylene at pressures higher than 15 pounds per square inch.

> Caution: Acetylene becomes unstable and highly explosive when pressure is over 15 psi.

bb. Be sure that floor is dry. Do not stand in water when welding.

cc. Do not cut or weld directly on gravel or concrete.

dd. Keep tools and materials in proper locations.

Objective 3

Welding materials and their descriptions

a. **Cast iron**—Commercial alloy of iron, carbon, and silicon that is cast in a mold and is hard, brittle, nonmalleable, and incapable of being hammer-welded

b. **Low-carbon steel**—Steel containing 0.2 percent or less carbon

c. **Mild steel**—Steel containing from 0.2 to 0.5 percent carbon

Objective 4

Basic arc welding circuit

Note: Arc welding uses an arc from an electrode to heat base metal pieces for fusion.

a. The current for the arc is supplied by a welding machine with two cables, one of which terminates in the electrode, the other in a ground clamp which is connected to the base metal.

b. Current arcs from the base metal to the ground clamp, heating the base metal and melting the electrode's metal core, which drips into and fills the gaps between the pieces of base metal.

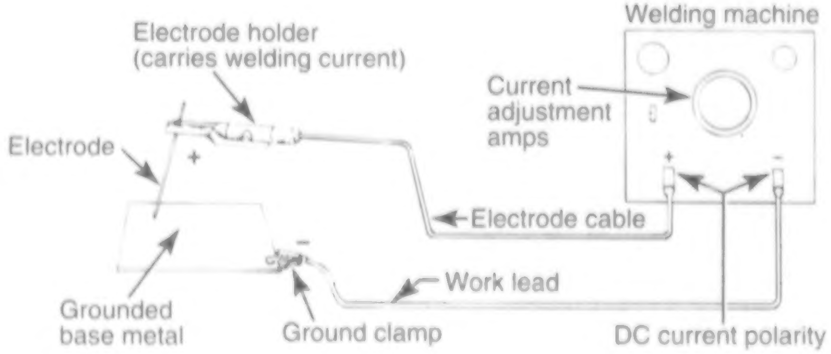

Welding machine
Electrode holder (carries welding current)
Current adjustment amps
Electrode
+
+
-
Electrode cable
-
Work lead
Grounded base metal
Ground clamp
DC current polarity

Figure 2—Arc welding circuit

Objective 5

Parts of the arc welding process

a. **Electrode**—Metal rod that conducts a current from electrode holder to base metal in arc welding

Note: The electrode melts and deposits metal in a bead.

b. **Wire core**—Metal center of electrode

c. **Flux**—Coating on outside of electrode; chemical used to promote fusion during welding process

d. **Arc**—Flow of electric current across a narrow gap, usually from tip of electrode to base metal

e. **Gaseous shield**—Gas given off by melting of electrode flux

f. **Weld**—Area joined by the process

g. **Slag**—Waste materials (impurities) that form on the surface of molten metal during the welding or cutting process

h. **Heat line (heat-affected zone)**—That part of base metal altered by heat from welding, brazing, or cutting operations

i. **Base metal**—Metal to be welded

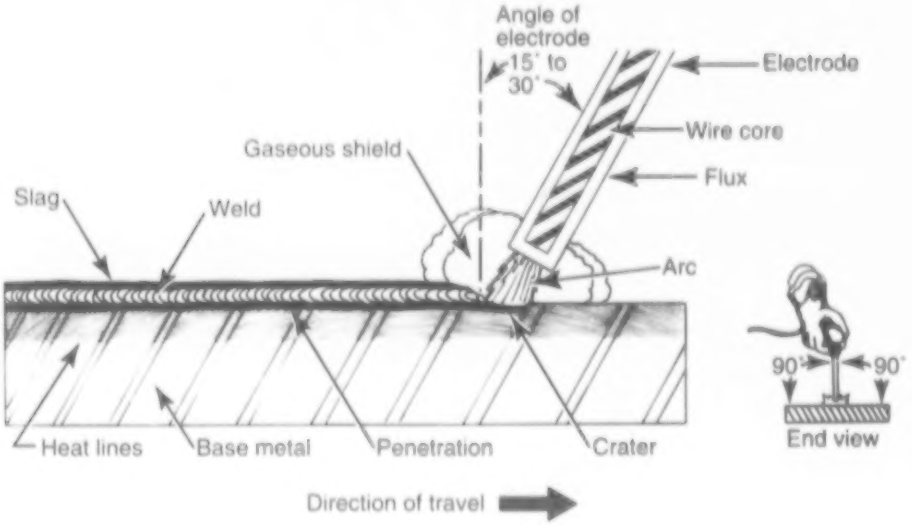
j. **Penetration**—Distance from original surface of base metal to that point at which fusion ceases

k. **Crater**—Depression at termination of weld

l. **Angle of electrode**—Should be held 15° to 30° less than 90° into the direction of travel

m. **Direction of travel**—Course of the electrode's movement

Figure 3—Parts of the arc welding process


Angle of electrode 15° to 30°
Electrode
Wire core
Flux
Gaseous shield
Slag
Weld
Arc
90°
90°
End view
Heat lines
Base metal
Penetration
Crater
Direction of travel

Objective 6

Types of arc welding machines

a. Alternating-current (AC) transformer welder

b. Direct-current (DC) welder

c. Electric motor generator (produces DC)

d. Engine generator (produces either AC or DC)

e. AC/DC transformer rectifier (produces either AC or DC)

Objective 7

Polarity

a. Reverse (+) polarity (RP)—Current flows from base metal to electrode

b. Straight (–) polarity (SP)—Current flows from electrode to base metal

Note: Welding leads must connect to correct terminals if the machine has a polarity switch. Otherwise, polarity is changed by reversing leads on the terminals.

c. Factors that determine correct polarity

- Type of electrode
- Type of flux on electrode

Note: *Use Electrode Guidebook* to determine correct polarity for different electrodes.

Examples:
E-6011—Reverse (+) polarity
E-6013—Either (+ or −) polarity
E-7014—Straight (−) polarity

Objective 8

Effects of raising and lowering amperes in current from welding machine

a. Raising amperes produces more heat, increases penetration.

b. Lowering amperes produces less heat, decreases penetration.

Objective 9

Common types of arc welding electrodes and their descriptions

a. **Mild steel (most common)**—All-purpose for most general repair work on autos, trucks, farm equipment, pipe, tanks, and structural steel

b. **Cutting**—Cuts metals quickly and easily; does not require oxygen or special equipment

c. **Nickel**—For use on all cast iron; finished weld is machinable

d. **Low hydrogen**—General purpose contact type; joins most hard-to-weld steels (high sulfur, low alloy, medium and high carbon, and cold rolled)

Objective 10

Common diameter sizes of arc welding electrodes

a. 3/32 inches

b. 1/8 inches

c. 5/32 inches

d. 3/16 inches

Note: Electrodes are also available in different lengths with 14 inches the most common.

Information Sheet

Objective 11

Meanings of numbers in the AWS electrode classification system

a. First two digits—Minimum tensile strength

b. Third digit—Welding position

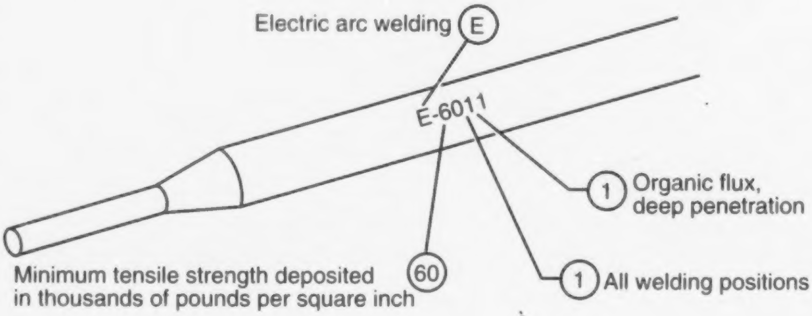
- 1—Indicates all positions
- 2—Indicates flat and horizontal only
- 3—Indicates flat only

c. Fourth or last digit—Special characteristics and uses of the electrode (Table 1)

Table 1—Last-digit characteristics

Last Digit	Power Supply	Arc Action	Type of Flux	Penetration Characteristics
0	10, DCRP (+)	Digging	10, organic	10, deep
	20, AC or DC		20, mineral	20, medium
1	AC or DCRP (+)	Digging	Organic	Deep
2	AC or DC	Medium	Ductile	Medium
3	AC or DC	Soft	Ductile	Light
4	AC or DC	Soft	Ductile	Light
5	DCRP (+)	Medium	Low hydrogen	Medium
6	AC or DCRP (+)	Medium	Low hydrogen	Medium
7	AC or DC	Soft	Mineral	Medium
8	AC or DCRP (+)	Medium	Low hydrogen	Medium

Figure 4—Example of an AWS electrode with numbers classified


Electric arc welding
E
E-6011
1 Organic flux, deep penetration
Minimum tensile strength deposited in thousands of pounds per square inch
60
1 All welding positions

Objective 12

Factors to consider when selecting electrodes

a. Composition of base metal

b. Thickness and shape of base metal

c. Welding position

d. Welding current

Objective 13

Purposes of flux on electrodes

a. Stabilize arc

b. Shield molten puddle from air

c. Float impurities out of puddle

d. Form slag and slow down cooling

e. Increase welding speed

f. Improve weld quality

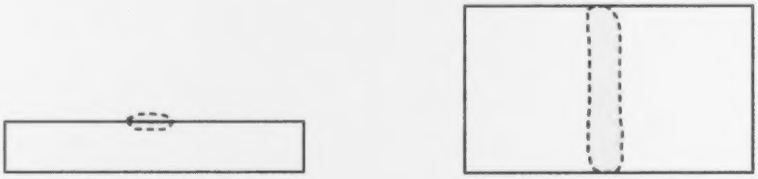
g. Add alloy elements to weld metal

Objective 14

Types of weld

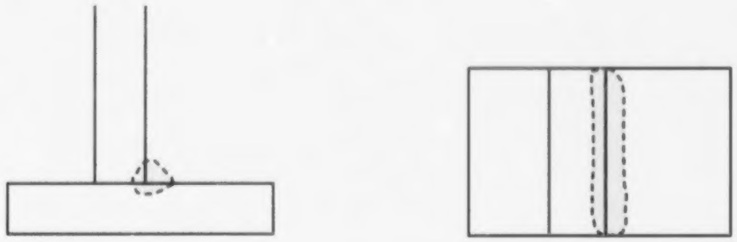
a. **Basic weld**—Weld made by one pass of electrode

Figure 5



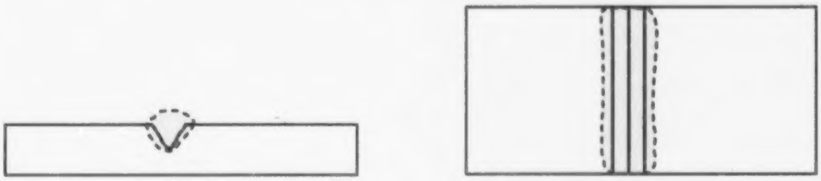
b. **Fillet weld**—Weld made in corner or angle formed by two pieces of metal with welded surfaces at approximately 90° angles to each other

Figure 6



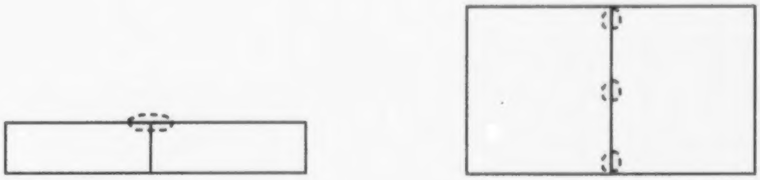
c. **Groove weld**—Weld made in groove formed by two beveled pieces of metal

Figure 7



d. **Tack weld**—Temporary weld made to hold parts in alignment until final welds are made

Figure 8

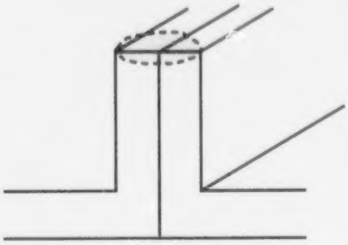


Objective 15

Types of weld joints

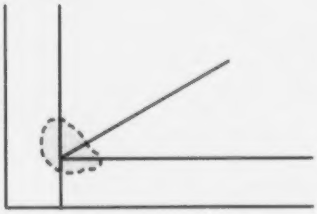
a. Edge

Figure 9



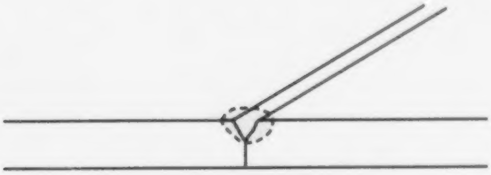
b. Corner

Figure 10



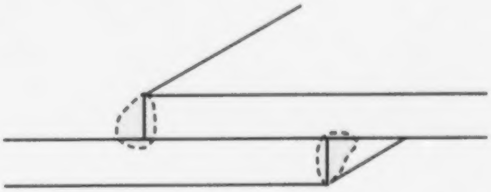
c. Butt

Figure 11



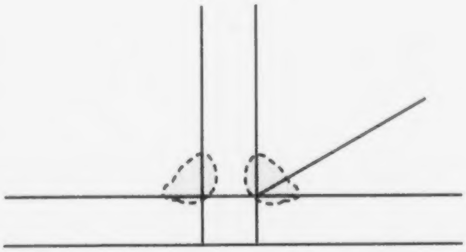
d. Lap

Figure 12



e. T (or tee)

Figure 13



Objective 16

Characteristics of a good weld

a. Smooth edges

b. Clean, bright weld

c. Correct bead size

d. Even penetration (well fused)

e. Even ripple

f. Slight crown

Objective 17

Reasons for poor weld

a. Incorrect machine adjustment

b. Too large or too small electrode

c. Improper angle of electrode

d. Improper preparation of base metal

e. Incorrect arc length

f. Improper movement of electrode

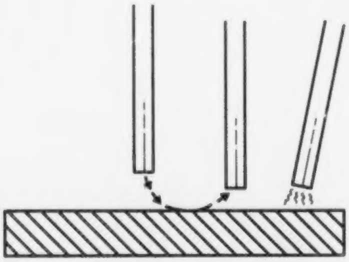
Note: You must consider rate of travel and pattern of movement of the electrode.

Objective 18

Methods of striking an arc

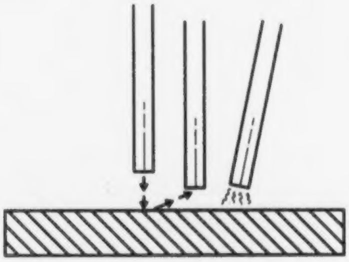
a. Scratching (similar to striking a match)

Figure 14



b. Tapping

Figure 15



Objective 19

Characteristics of proper arc length

a. End of electrode same distance from base metal as diameter of electrode

Example: When using 1/8-inch electrode, arc length should be 1/8 inch.

b. Arc length making steady hum at welder and frying sound at arc

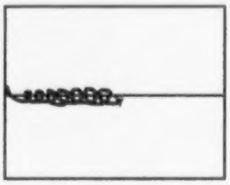
Objective 20

Types of electrode motions (rod manipulations)

Note: Most operators use all of these motions, depending upon the type of seam, type of joint, size of weld, and position of weld. On a single-layer weld, to ensure proper fusion in the root zone, the arc may progress with a straight, forward motion or an oscillating motion, depending on size of joint to be filled.

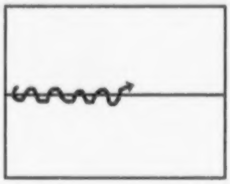
a. Small oscillating motion

Figure 16



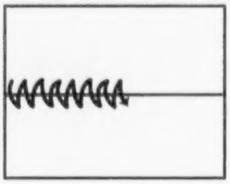
b. Small circular motion

Figure 17



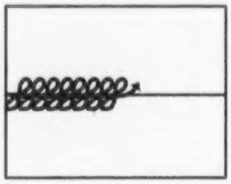
c. Back-and-forth motion with half circle

Figure 18



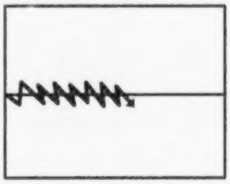
d. Figure-eight motion

Figure 19



e. Triangular motion

Figure 20

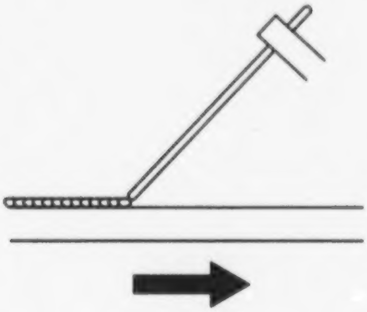


Objective 21

Positions used in arc welding

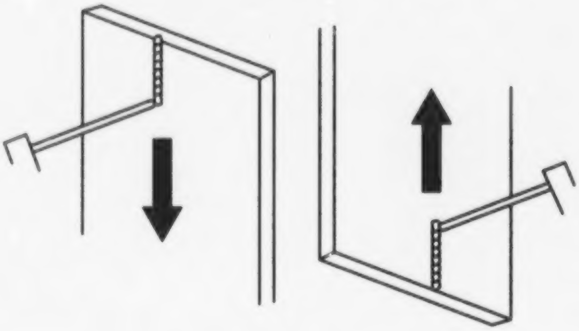
a. Flat

Figure 21



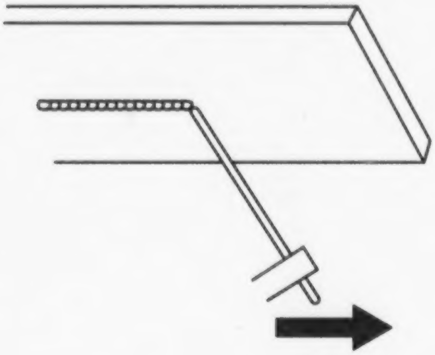
b. Vertical

Figure 22



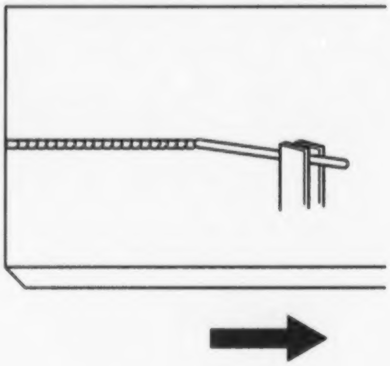
c. Overhead

Figure 23



d. Horizontal

Figure 24

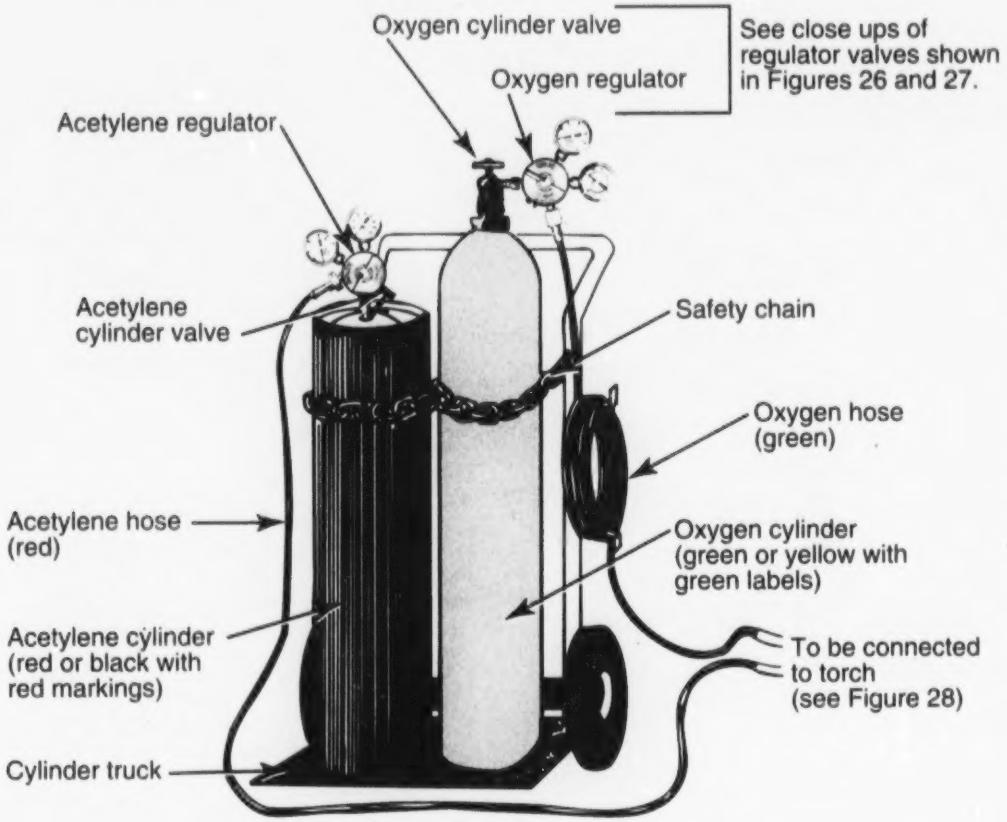


Objective 22

Parts of an oxyacetylene outfit

Note: Oxyacetylene welding and cutting uses a flame of oxygen mixed with acetylene to heat base metal.

Figure 25


Oxygen cylinder valve
Oxygen regulator
Acetylene regulator
Acetylene cylinder valve
Safety chain
Oxygen hose (green)
Acetylene hose (red)
Oxygen cylinder (green or yellow with green labels)
Acetylene cylinder (red or black with red markings)
To be connected to torch (see Figure 28)
Cylinder truck

See close ups of regulator valves shown in Figures 26 and 27.

Note: As an added safety feature, some outfits are equipped with anti-flashback valves between regulator and torch.

Figure 26—Oxygen regulator valve

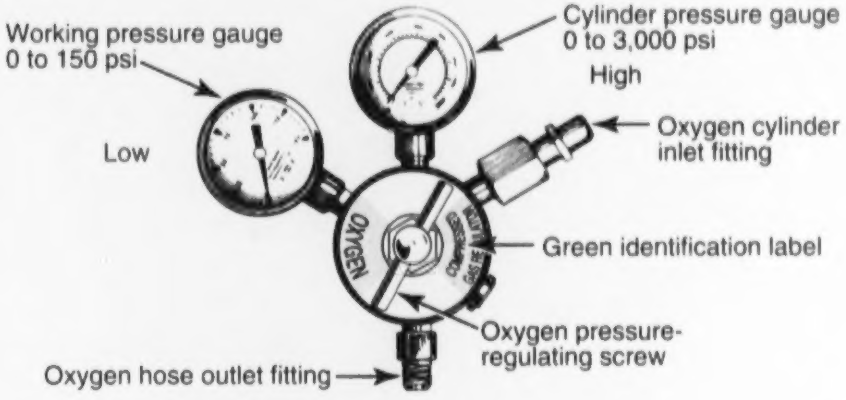

Working pressure gauge
0 to 150 psi
Low
Cylinder pressure gauge
0 to 3,000 psi
High
Oxygen cylinder
inlet fitting
OXYGEN
COMPRESSED
GAS REGULATOR
Green identification label
Oxygen pressure-
regulating screw
Oxygen hose outlet fitting

Figure 27—Acetylene regulator valve

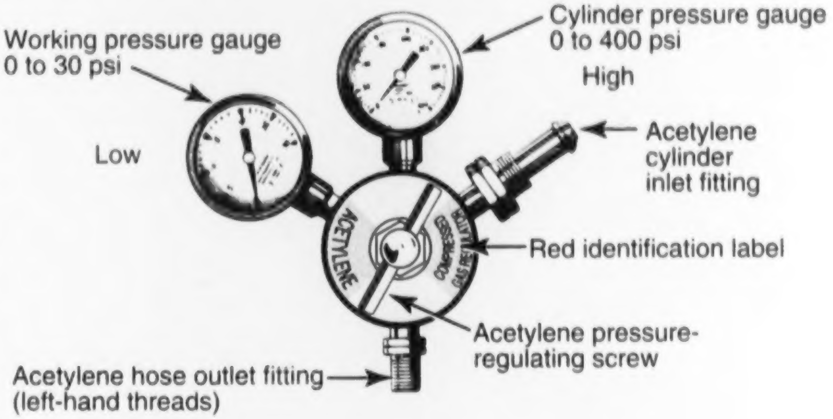
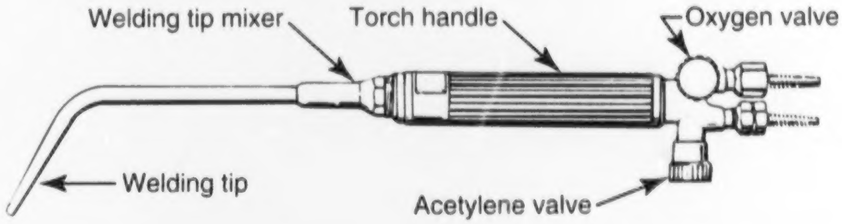

Working pressure gauge
0 to 30 psi
Low
Cylinder pressure gauge
0 to 400 psi
High
Acetylene
cylinder
inlet fitting
ACETYLENE
COMPRESSED
GAS REGULATOR
Red identification label
Acetylene pressure-
regulating screw
Acetylene hose outlet fitting
(left-hand threads)

Figure 28—Welding torch


Welding tip mixer
Torch handle
Oxygen valve
Welding tip
Acetylene valve

Note: The most common welding tip sizes are 1, 3, 5, and 7.

Objective 23

Factors that determine selection of welding tip size

a. Size of welding electrode (rod)

b. Thickness of base metal

Table 2

Thickness of Metal to be Welded	Welding Tip Size	Oxygen and Acetylene Regulator Setting (PSI)
Up to 1/32"	1	1
1/32" to 1/16"	3	3
1/16"	5	5
1/8" to 1/4"	7	7

Note: Follow manufacturer's recommendations when selecting tip size.

Objective 24

Stages of oxyacetylene torch combustion

a. Two cylinders provide pressure-regulated acetylene and pressure-regulated compressed oxygen.

b. Separate, flexible hoses carry gases to the torch. Two needle valves control the flow of gas.

c. Operator ignites acetylene gas with spark from flint lighter.

d. Operator opens oxygen torch valve, and gases are mixed inside torch.

e. Mixture burns at torch tip.

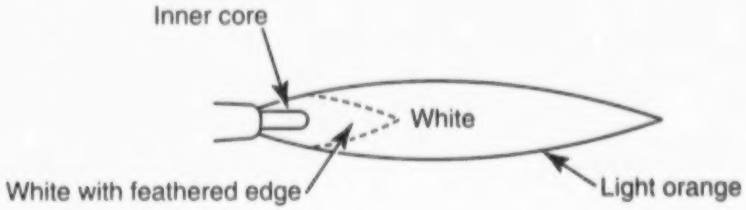
Objective 25

Types of oxyacetylene flames

a. **Carburizing flame**

- Burns excess of acetylene
- Introduces carbon into weld, causing hardening of the metal which weakens weld

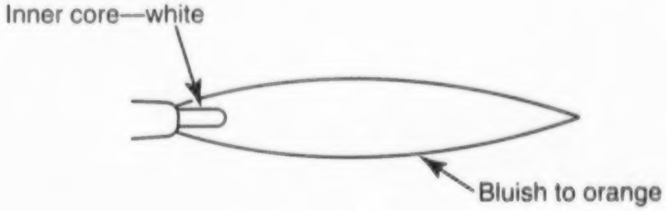
Figure 29


Inner core
White
White with feathered edge
Light orange

b. **Neutral flame**

- Burns equal amounts of oxygen and acetylene
- Is identified by clear, well-defined white cone
- Preferred for most welding tasks

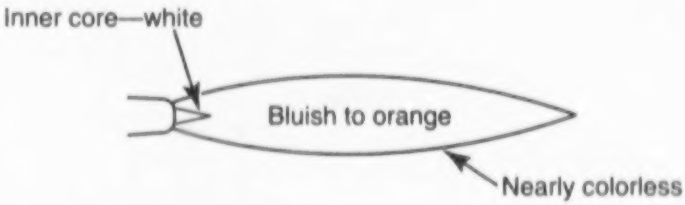
Figure 30


Inner core—white
Bluish to orange

c. **Oxidizing flame**

- Burns excess of oxygen
- Is identified by short, white inner cone
- Oxidizes the metal, causing it to harden and become brittle
- Is hottest flame
- Recommended for brazing

Figure 31



Objective 26

Definitions of flashback and backfire

a. **Flashback**—Flame disappears inside torch body; at the same time, a squealing noise occurs and smoke and/or sparks are emitted from the torch tip

b. **Backfire**—Flame burns momentarily back into tip; then a loud snap or pop is emitted from the torch and the flame either goes out or continues to burn in a normal manner

Objective 27

Steps to follow in case of flashback

a. Close oxygen preheat valve.
b. Close oxygen torch valve.
c. Close acetylene torch valve.
d. Release oxygen pressure-regulating screw.
e. Release acetylene pressure-regulating screw.
f. Examine acetylene unit.
g. Reset regulator pressures.
h. Light torch.

Note: If heavy smoke comes out of the torch tip and the torch body becomes hot, the flashback has probably traveled past the mixing chamber into the hose. In this case, shut off the oxygen and acetylene cylinders, and then notify your supervisor.

Objective 28

Causes of backfire

Note: The causes listed below should be carefully checked to control backfire.

a. Not enough acetylene or oxygen pressure for the tip size used

b. Loose cutting tip

c. Dirty tip

Note: Tip may have deposits or metal particles inside orifice. These deposits may overheat and act as ignitors.

d. Overheating of cutting tip

e. Bad o-ring in torch body

Objective 29

Oxyacetylene braze welding

Note: Braze welding uses molten bronze to join two pieces of base metal, whereas fusion welding heats the two pieces of base metal until they fuse together.

a. Advantages of braze welding over fusion welding

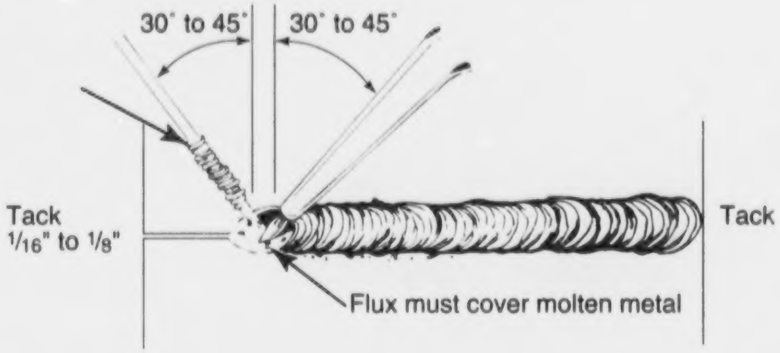
- Main characteristics of base metal are less likely to be destroyed because it is not heated to molten state.
- Uses less gas
- Can be used to weld thin metals, malleable castings, and different kinds of metals
- Increases speed of joining metals

b. Disadvantages of braze welding compared to fusion welding

- Cannot be used on metal where stress is a factor
- Bronze rod is expensive
- Is not recommended for parts that are raised to temperatures higher than melting point of bronze (1125°F to 1760°F), either in service or during heat treatment
- Bronze loses its strength at temperatures above 500°F.
- Will not bond unless base metal has corrosion-resistant properties similar to bronze

876

Figure 32—Oxyacetylene braze welded butt joint



Objective 30

Importance of having a chemically clean metal surface in braze welding

a. Ensures that the molten bronze will adhere to base metal

b. Allows weld to form stronger bond on base metal

c. Allows bronze to flow smoothly and evenly over entire weld area

Objective 31

Methods of removing oxides from a metal surface

a. Mechanical means such as a wire brush or grinder

b. Chemical flux

Note: Both methods should be used to completely remove oxides.

Objective 32

Reactions of molten bronze at different base metal temperatures

a. Correct—Spreads evenly and flows over a considerable area

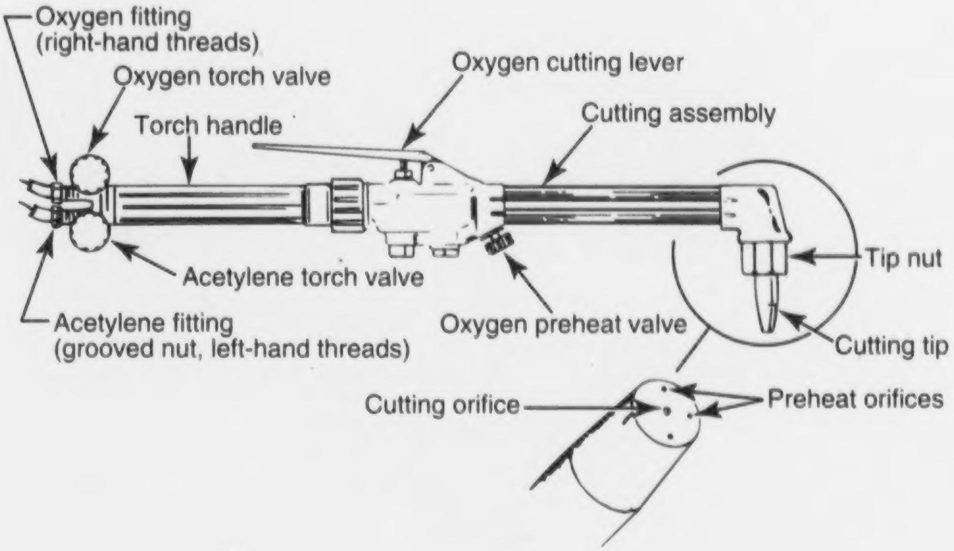
b. Too hot—Tends to boil and form little balls

c. Too cold—Forms into drops rather than flowing evenly over surface

Objective 33

Parts of a torch body and cutting attachment

Figure 33


Oxygen fitting (right-hand threads)
Oxygen torch valve
Torch handle
Oxygen cutting lever
Cutting assembly
Tip nut
Acetylene torch valve
Cutting tip
Acetylene fitting (grooved nut, left-hand threads)
Oxygen preheat valve
Cutting orifice
Preheat orifices

Note: The preheat orifices in the tip heat metal to approximately 1,600°F (755°C). The cutting orifice removes oxidized metal.

Student Supplement 1—Covered Electrodes for SMAW of Carbon Steel (per AWS A5.1)

Classification	Covering	Weld Position	Current	Characteristics, applications
E6010	High-cellulose sodium	F, V, O, H	dcep	A general purpose electrode for joining of carbon steel. Deep-penetrating forceful arc. Thin slag. Use in all positions, single and multiple pass, plate and pipe, galvanized and alloy steel. Ships, bridges, buildings, piping, tanks, pressure-vessel fittings.
E6011	High-cellulose potassium	F, V, O, H	ac, dcep	Similar to E6010, but for use with ac. Dcep gives reduced penetration.
E6012	High-titania sodium	F,V, O, H	ac, dcen	Dense slag that covers the bead, low penetrating arc. Use to bridge joints with poor fitup. Fillets have smooth convex face. Runs well at amps higher than E6010/E6011.
E6013	High-titania potassium	F,V, O, H	ac, dcen, dcep	Similar to E6012; quieter arc, smoother bead, cleaner weld metal, fewer inclusions. Characteristics vary with supplier. Run at lower current than for E6012.
E6022	High iron oxide	F	ac, dcep, dcen	Use for single-pass, high-current, high-speed welding of groove welds in flat position horizontal lap joints & fillet welds in sheet metal.
E6027	High iron oxide, iron powder	H-fillets, F	ac, dcep	For fillet of groove welds, flat position, heavy slag, good sidewall fusion. Use at high amperages on thick plate.
E7014	Iron powder, titania	F, V, O, H	ac, dcep	Iron powder boosts deposition rate and efficiency. Use at high amperages on carbon and low-alloy steels. Low-penetrating arc, use to bridge poor fitups. Smooth, fine-rippled bead, convex fillets.
E7018, 7018-1 7018R 7018-1R 7018H16, H8, H4	Low-hydrogen potassium, Iron powder	F, V, O, H	ac, dcep	Iron-powder addition increases deposition rate. Use on carbon, high-carbon, and low-alloy steels. Smooth arc, low spatter. Flat and horizontal welds are finely rippled. Convex.
E7018M	Low-hydrogen, Iron powder	F, V, O, H	dcep	Yield strength, 53,000-72,000 lb./in. Ductility high, extra impact strength and compositional limits & limits on moisture & hydrogen. Similar to E7018-1H4R, MIL-7018-M. Characteristics similar to E7018.
E7024 E7024-1	Iron powder, titania	H-fillets, F	ac, dcep, dcen	Iron powder for high deposition rate, high travel speed, flat, smooth fillets, finely rippled. Smooth, quiet arc, low penetration. E7024-1 deposits more-ductile weld metal of improved Charpy values.

Student Supplement 2—Recommended Amperages for Electrodes by Type and Diameter (Current Range, A)

Electrode Diameter (In.)	Electrode Type								
	6010, 6011	6012	6013	6020	6027	7014	7015, 7016	7018	7024, 7028
1/16	—	20-40	20-40	—	—	—	—	—	—
5/64	—	25-60	25-60	—	—	—	—	—	—
3/32	40-80	35-85	45-90	—	—	80-125	65-110	70-100	100-145
1/8	75-125	80-140	80-130	100-150	125-185	110-160	100-150	115-165	140-190
5/32	110-170	110-190	105-180	130-190	160-240	150-210	140-200	150-220	180-250
3/16	140-215	140-240	150-230	175-250	210-300	200-275	180-255	200-275	230-305
7/32	170-250	200-320	210-300	225-310	250-350	260-340	240-320	260-340	275-365
1/4	210-320	250-400	250-350	275-375	300-420	330-415	300-390	315-400	335-430
5/16	275-425	300-500	320-430	340-450	375-475	390-500	375-475	375-470	400-525

Student Supplement 3—Oxyacetylene Welding Parameters

Tip size	Drill size	Oxygen pressure, lb/in.^{2}	Acetylene pressure, lb/in.^{2}	Acetylene consumption, ft.^{3}/h*	Base metal thickness, in.
000	75	1/2-2	1/2-2	1/2-3	to 1/32
00	70	1-2	1-2	1-4	1/64-3/64
0	65	1-3	1-3	2-6	1/32-5/64
1	60	1-4	1-4	4-8	3/64-3/32
2	56	2-5	2-5	7-13	1/16-1/8
3	53	3-7	3-7	8-36	1/8-3/16
4	49	4-10	4-10	10-41	3/16-1/4
5	43	5-12	5-15	15-59	1/4-1/2
6	36	6-14	6-15	55-127	1/2-3/4
7	30	7-16	7-15	78-152	3/4-1 1/2
8	29	9-19	8-15	81-160	1 1/4-2
9	28	10-20	9-15	90-166	2-2 1/2
10	27	11-22	10-15	100-169	2 1/2-3
11	26	13-24	11-15	106-175	3-3 1/2
12	25	14-28	12-15	111-211	3 1/2-4

*Oxygen consumption is 1.1 times that of acetylene under neutral flame conditions. Gas consumption will vary depending on the material being welded and operator skill. Pressures are approximate for hose length up to 25 ft. Increase for longer hose lengths, about 1 lb/in^2 per 25 ft.

Student Supplement 4—Parameters for Oxyfuel Cutting

Material Thickness, In.	Recommended Tip Number	Oxygen Pressure Setting lb./in.^{2}g	Acetylene Pressure Setting, lb./in.^{2}g	Cutting Speed Range, in./min.
1/8	00	20-25	3-5	27-30
1/4	0	25-30	3-5	26-29
1/2	1	30-35	3-5	20-24
3/4	1	30-35	3-5	17-21
1	2	35-40	3-7	14-18
1-1/2	2	40-45	3-7	13-17
2	3	40-45	5-10	12-15
4	3	40-45	5-10	8-11
5	4	45-55	6-12	7-9
6	6	45-55	7-13	6-8
8	6	45-55	8-14	5-6
10	7	45-55	10-15	4-5
12	8	45-55	10-15	3-4

Objective 34

Job Sheet 1—Start, Stop, and Restart a Bead

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Prepared base metal correctly	______
• Started, stopped, and restarted bead correctly	______

Basic Skills

Reading · Critical Thinking · Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Piece of metal, 4 inches square, 1/4- to 3/8-inch thick
- Welding machine
- Electrode holder with lead
- Ground clamp with lead
- Shield or helmet
- Leather gloves
- Electrodes
- Wire brush
- Protective clothing—Long sleeves and pants or coveralls

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Prepare metal for welding.

☐ 2. Put on shield or helmet.

☐ 3. Strike arc by tapping or scratching 1 inch from edge where bead is to begin.

Figure 1

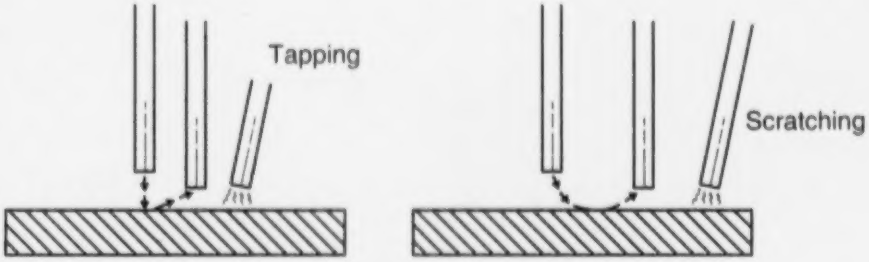
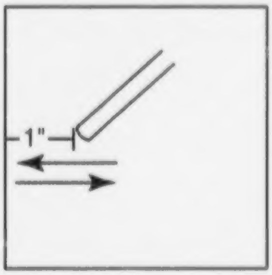


Figure 2



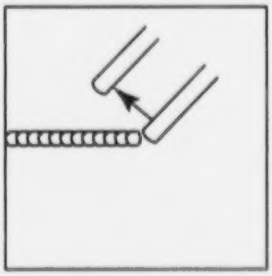
☐ 4. When arc burns brightly, move to edge, maintaining correct arc length; begin forming puddle.

☐ 5. Move across metal 2 inches.

☐ 6. Move electrode back through puddle, and lift up to stop bead.

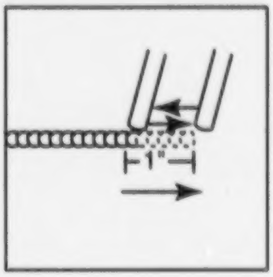
Note: Moving electrode through puddle will prevent cracks from forming in the puddle.

Figure 3



☐ 7. Strike arc about 1 inch in front of crater to restart.

Figure 4



☐ 8. When arc burns brightly, move back through crater, and continue the bead.

Note: Moving back through the crater is necessary in order for beads to blend with one another without a change in continuity.

☐ 9. Clean work area. Put away all equipment and materials.

Evaluator's Comments: ____

____

____

Objective 35

Job Sheet 2—Construct a Pad Weld

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Prepared base metal correctly	______
• Constructed pad weld correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Piece of metal, 4 inches square, 1/4- to 3/8-inch thick
- Welding machine
- Electrode holder with lead
- Ground clamp with lead
- Shield or helmet
- Leather gloves
- Electrodes
- Safety goggles
- Chipping hammer
- Wire brush
- Protective clothing—Long sleeves and pants or coveralls

Caution: Follow all shop safety procedures.

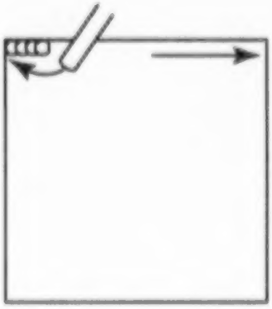
Procedure

☐ 1. Prepare metal for welding.

☐ 2. Put on shield or helmet.

☐ 3. Strike arc, and move to point to begin pad.

Figure 1



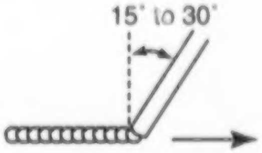
☐ 4. Lay a straight bead across the plate, using an oscillating motion.

Note: When using an E-6011 electrode, you must manipulate the rod to run a bead. Ask your instructor to explain this process.

☐ 5. Hold electrode at a 15° to 30° angle in direction of travel. To maintain correct arc length, lower electrode as rod burns away. (Figure 2)

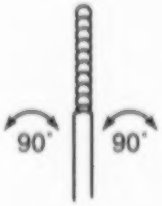
Note: There should be 90° on each side of the electrode. See Figure 3.

Figure 2



Front View

Figure 3



End View

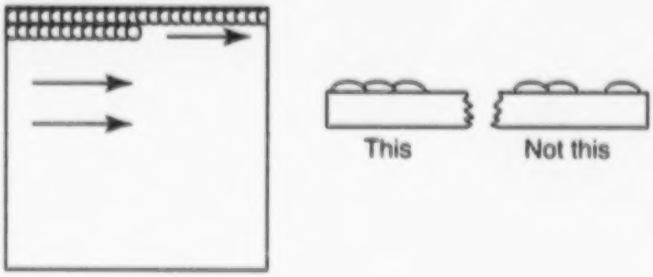
☐ 6. Move electrode steadily from left to right across pad if you are right-handed. Reverse direction if left-handed.

☐ 7. Clean slag from each bead before starting next one.

887

☐ 8. Run beads, overlapping each bead until pad is full.

Figure 4


Overlap about one-third of bead

☐ 9. Before chipping, let each bead cool until slag is black.

☐ 10. Run additional bead layers until desired thickness is obtained.

☐ 11. Clean work area. Put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 36

Job Sheet 3—Construct a Butt Weld

Name ______________________ Attempt Number ______

Date ______________________ Overall Rating ______

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Prepared and positioned two pieces of base metal correctly	______
• Constructed butt weld correctly	______
• Chipped slag and brushed weld correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Two pieces of metal, 3 by 6 inches, 1/4- to 3/8-inch thick
- Welding machine
- Electrode holder with lead
- Ground clamp with lead
- Shield or helmet
- Leather gloves
- Electrodes
- Safety goggles
- Chipping hammer
- Wire brush
- Protective clothing—Long sleeves and pants or coveralls

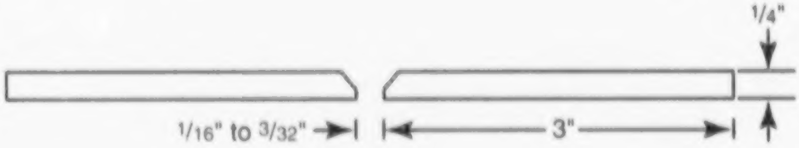
Caution: Follow all shop safety procedures.

Procedure

☐ 1. Prepare metal to be welded.

Note: If metal thickness is over 1/8 inch, the edges should be beveled.

Figure 1



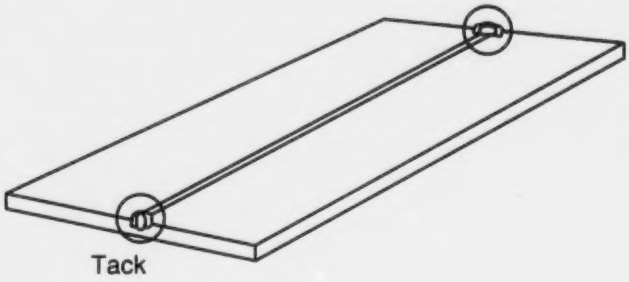
☐ 2. Place two pieces of metal parallel to each other.

Note: Leave a space of 1/16 to 3/32 inch between them.

☐ 3. Put on shield or helmet.

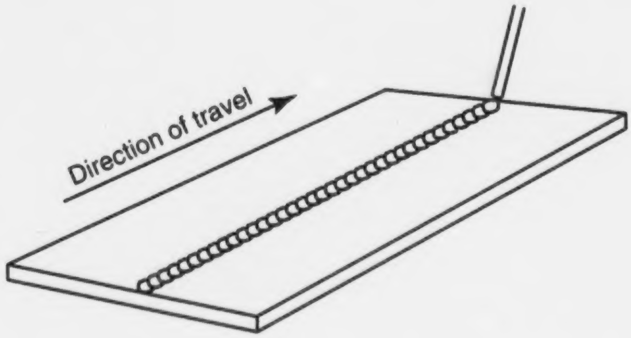
☐ 4. Strike an arc, and tack-weld pieces together at both ends.

Figure 2



☐ 5. Complete weld using a single pass.

Figure 3



☐ 6. Chip slag. Brush the weld.

☐ 7. Clean work area. Put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

890

Objective 37

Job Sheet 4—Construct a Lap-Joint Fillet Weld in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Adjusted welding machine to correct settings	______
• Prepared base metal and positioned pieces correctly	______
• Constructed lap-joint fillet weld correctly	______
• Cleaned plates correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Arc-welding station and required tools
- Two pieces mild-steel plate, 2 by 6 inches, 1/4- to 3/8-inch thick
- Electrode E-6010, 1/8- to 5/32-inch diameter
  - — 1/8-inch–75 to 130 amperes
  - — 5/32-inch–90 to 175 amperes
- Current DCRP + at electrode
- Chipping hammer
- Wire brush
- Leather gloves
- Shield or helmet
- Protective clothing—Long sleeves and pants or coveralls

Caution: Follow all shop safety procedures.

Procedure

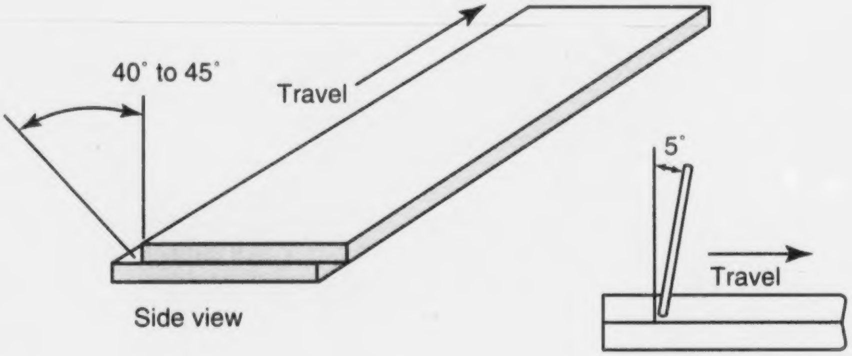
☐ 1. Adjust welding machine to correct current and amperage setting.

☐ 2. Put on shield or helmet.

☐ 3. Prepare metal, and tack plate together for a 90° lap joint in the flat position.

☐ 4. Position electrode 40° to 45° out from vertical and inclined 5° in direction of travel.

Figure 1



☐ 5. Strike arc, and establish a puddle evenly on both pieces.

Note: Be sure to get good penetration into root of joint without undercutting or overlapping plates. Some form of whipping motion will be needed.

☐ 6. After depositing first bead (root pass), the weld should be chipped, brushed clean, and checked for bead appearance.

☐ 7. Deposit additional beads if necessary as stringers or weaves.

☐ 8. Clean plates.

☐ 9. Clean work area. Put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 38

Job Sheet 5—Construct a T-Joint Fillet Weld in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Adjusted welding machine to correct settings	______
• Prepared base metal and positioned pieces correctly	______
• Constructed T-joint fillet weld correctly	______
• Cleaned plates correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Arc-welding station and required tools
- Two pieces mild-steel plate, 2 by 6 inches, 1/4- to 3/8-inch thick
- Electrode E-6010, 1/8- to 5/32-inch diameter
  - — 1/8-inch–75 to 130 amperes
  - — 5/32-inch–90 to 175 amperes
- Current DCRP + at electrode
- Chipping hammer
- Wire brush
- Leather gloves
- Shield or helmet
- Protective clothing—Long sleeves and pants or coveralls

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Adjust welding machine to correct current and amperage setting.

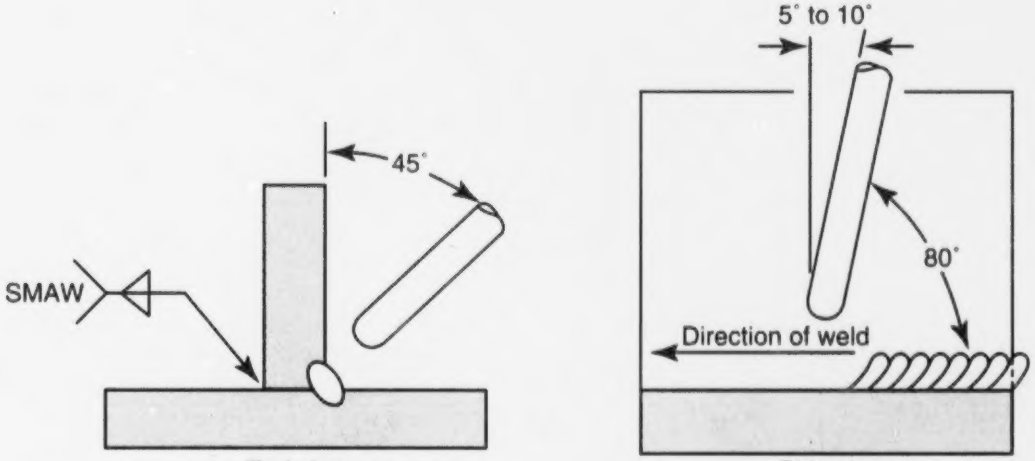
☐ 2. Put on shield or helmet.

☐ 3. Prepare metal, and tack in flat position. Remove slag.

☐ 4. Strike arc on one end of joint. Hold a high arc length for one to two seconds to heat plates.

☐ 5. Position electrode in middle of joint, making a 45° angle with each plate and holding electrode 5° to 10° from vertical

Figure 1—Electrode position of flat T-joint



End view

Side view

☐ 6. Deposit weld using some form of side-to-side whipping motion.

Note: Bead uniformity depends upon proper timing and manipulation of electrode. Check with instructor for correct procedures.

☐ 7. Remove slag and clean thoroughly after each pass.

☐ 8. Alternate sides to minimize distortion.

Note: Check with instructor at this point. Upon receiving instructor's approval, additional beads may be stringers or some form of weave bead.

☐ 9. Clean work area. Put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 39

Job Sheet 6—Set Up Equipment for Oxyacetylene Welding/Cutting

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Set up cylinders and connected regulators correctly	______
• Connected hoses and torch correctly	______
• Adjusted valves and regulating screws correctly	______
• Tested connections and closed valves correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxygen cylinder
- Acetylene cylinder
- Oxygen regulator
- Acetylene regulator
- Hoses
- Wrench
- Cylinder truck
- Foam or multipurpose dry-chemical fire extinguisher
- Soapsuds (Ivory® soap is recommended)
- Clean paintbrush
- Torch body with tips
- Welding goggles, shield, or helmet
- Protective clothing—Long sleeves and pants or coveralls

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Fasten cylinders in a vertical position on cylinder truck.

Caution: To prevent damage to valves, never use acetylene from a cylinder that is not in a vertical position. Valve damage might cause cylinder to explode.

☐ 2. Remove caps from cylinders.

☐ 3. Crack valves of each cylinder to remove foreign material. Close valves.

☐ 4. Connect oxygen regulator to oxygen cylinder.

> Caution: Do not use oil or any thread compound on any connections in the oxyacetylene system.

- ☐ a. Turn oxygen pressure-regulating screw counterclockwise until tension on spring is released.
- ☐ b. Slowly turn cylinder valve wide open.

☐ 5. Connect acetylene regulator to acetylene cylinder.

- ☐ a. Turn acetylene pressure-regulating screw counterclockwise until tension on spring is released.
- ☐ b. Open cylinder valve one-half to three-quarters of a turn.

  Note: Never open cylinder valve more than one and one-half turns. Leave wrench with cylinder.

☐ 6. Connect acetylene hose to acetylene regulator. Purge hose.

☐ 7. Connect oxygen hose to oxygen regulator. Purge hose.

☐ 8. Connect torch body to oxygen and acetylene hoses.

☐ 9. Close both valves on torch body.

☐ 10. Attach cutting attachment or welding tip to torch body.

Note: The tip size is determined by the thickness of metal to be cut or welded and the manufacturer's instructions.

☐ 11. Close oxygen preheat valve on cutting attachment if used.

☐ 12. Turn oxygen pressure-regulating screw clockwise until working pressure is reached.

☐ 13. Turn acetylene pressure-regulating screw clockwise until correct working pressure is reached.

> Caution: At pressure higher than 15 psi, acetylene becomes unstable and highly explosive.

☐ 14. Apply soapsuds with a clean paintbrush to test all connections for leaks.

☐ 15. Close regulator valves.

☐ 16. Proceed to next job sheet.

Evaluator's Comments: ____________________

Objective 40

Job Sheet 7—Turn On, Light, Adjust, and Shut Down Oxyacetylene Welding Equipment

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Checked valves and pressure regulating screws and adjusted correctly	______
• Connected hoses and torch correctly	______
• Lit torch and adjusted flame correctly	______
• Closed valves and shut down outfit correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene cutting outfit with tip assembly
- Wrench
- Welding gloves
- Welding goggles, shield, or helmet
- Protective clothing—Long sleeves and pants or coveralls
- Flint lighter
- Foam or multipurpose dry-chemical fire extinguisher
- Tip cleaners

Caution: Follow all shop safety procedures.

Procedure

Turn on, light, and adjust

☐ 1. Check all cylinder, regulator, and torch valves to make sure that they are closed.

☐ 2. Open acetylene cylinder valve one-half to three-quarters of a turn.

Caution: Never open acetylene cylinder valve more than one and one-half turns.

☐ 3. Open acetylene valve on torch one turn.

☐ 4. Turn acetylene pressure-regulating screw clockwise until desired pressure is reached.

Note: Oxygen and acetylene pressures and size of tip depend upon the thickness of metal to be cut. Use pressures and tip size recommended by manufacturer.

> Caution: Acetylene becomes unstable and highly explosive at pressures higher than 15 psi.

☐ 5. Close acetylene valve on torch.

☐ 6. Open oxygen cylinder valve all the way.

☐ 7. Open oxygen torch valve all the way.

☐ 8. Open oxygen preheat valve on cutting attachment one turn.

☐ 9. Turn oxygen pressure-regulating screw clockwise until desired pressure is reached.

☐ 10. Close oxygen preheat valve on cutting attachment.

☐ 11. Clean tip before lighting torch and as often as needed.

☐ 12. Open acetylene valve on torch one-quarter turn.

☐ 13. Light torch with flint lighter and adjust until smoke on flame clears.

☐ 14. Open oxygen preheat valve slowly and adjust to a neutral flame.

Note: Further adjustment may be necessary when cutting lever is activated.

Procedure

Turn off and shut down

☐ 1. Close acetylene valve on torch to quench flame.

☐ 2. Close oxygen preheat valve.

☐ 3. Close acetylene cylinder valve.

☐ 4. Close oxygen cylinder valve.

☐ 5. Open acetylene valve on torch.

Note: When gauges reach zero, close torch valve and release acetylene pressure-regulating screw by turning counterclockwise.

☐ 6. Open oxygen preheat valve on torch.

Note: When gauges reach zero, close oxygen preheat valve and turn oxygen pressure-regulating screw counterclockwise.

☐ 7. Close oxygen valve on torch.

☐ 8. Place torch and hose on hanger or brackets provided.

Note: If regulators are removed from cylinders, replace the caps.

☐ 9. Clean work area. Clean and put away all tools and equipment.

Evaluator's Comments: ______________________________

____

____

Objective 41

Job Sheet 8—Braze Weld a Lap Joint

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	_____
• Prepared base metal and positioned pieces correctly	_____
• Adjusted working pressure and flame correctly	_____
• Braze welded lap joint correctly	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene welding unit
- Gloves
- Welding goggles, shield, or helmet
- Protective clothing—Long sleeves and pants or coveralls
- Manufacturer's recommended weld tip, or #5
- Wire brush
- Flint lighter
- 2 firebricks
- 2 strips mild steel, 1 1/4" x 6" x 1/8"
- Manufacturer's recommended bronze filler rod
- Welding flux
- Service manual for oxyacetylene unit

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Clean metal.

☐ 2. Place metal on firebricks.

☐ 3. Place metal in brazing position, each strip overlapping the other ½ inch.

☐ 4. Turn on oxyacetylene unit.

☐ 5. Adjust working pressure of oxygen and acetylene to 5 pounds.

Note: Follow manufacturer's recommendations.

☐ 6. Light torch and adjust to a neutral or slightly oxidizing flame.

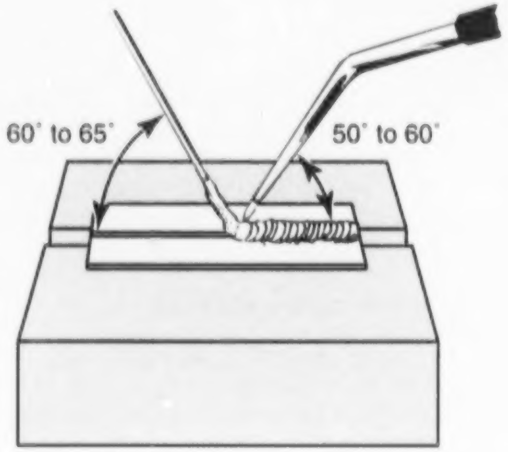
☐ 7. Preheat end of brazing rod and dip into flux, or use fluxed rod.

☐ 8. Tack metal in place using braze filler metal.

☐ 9. Preheat joint at right end; weld to left.

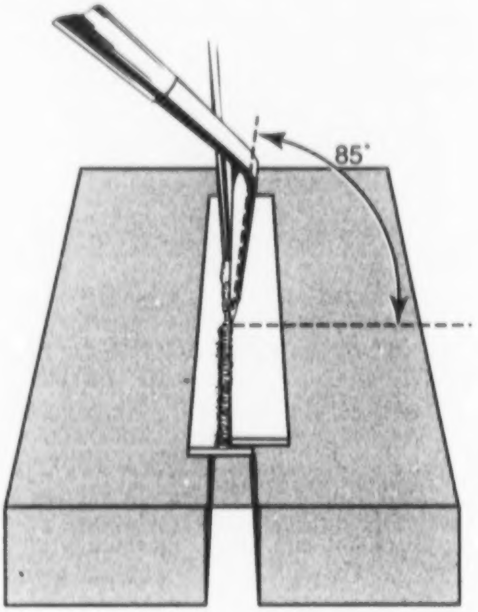
☐ 10. Hold torch and filler rod as shown in Figures 1 and 2.

Figure 1



902

Figure 2



☐ 11. Melt a small amount of bronze rod onto surface. Allow it to spread along entire width of seam when a cherry red color occurs.

☐ 12. Start depositing proper size bead when base metal is tinned sufficiently.

Note: When metal is not hot enough, the bronze will form into drops. When metal is too hot, bronze tends to boil.

☐ 13. Complete weld and show to instructor for evaluation.

☐ 14. Clean work area. Clean and put away all tools and equipment.

Evaluator's Comments: ______________________________

____

____

Objective 42

Job Sheet 9—Cut Mild Steel at 90° Angle, Stop, and Restart the Cut

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Attached cutting torch body and cutting tip correctly	______
• Marked workpiece correctly	______
• Adjusted working pressure and flame correctly	______
• Cut workpiece, stopped, and restarted cut correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene cutting outfit with tip assembly
- Mild steel plate, approximately 1/4" x 4" x 8"
- Soapstone with a sharp point or edge
- Straight edge
- Welding gloves
- Welding goggles, shield, or helmet
- Protective clothing—Long sleeves and pants or coveralls
- Pliers
- Flint lighter
- Welding or cutting table
- Slag box
- Can of water
- Cutting tip
- Foam or multipurpose dry-chemical fire extinguisher
- Tip cleaners

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Turn on equipment as outlined in Job Sheet 7.

☐ 2. To make a 90° cut:

  ☐ a. Mark four parallel lines 2 inches apart on plate to be cut.

☐ b. Adjust oxygen regulator.

☐ c. Adjust acetylene regulator.

☐ d. Place plate to be cut over slag box.

☐ e. Clean tip.

Note: Clean tip before lighting torch and as often as needed.

☐ f. Light torch with flint lighter.

☐ g. Adjust to neutral flame.

☐ h. Place hoses behind you.

☐ i. Assume comfortable position.

☐ j. Maneuver torch as required.

Note: Sometimes you must use both hands to hold torch steady for a straight cut.

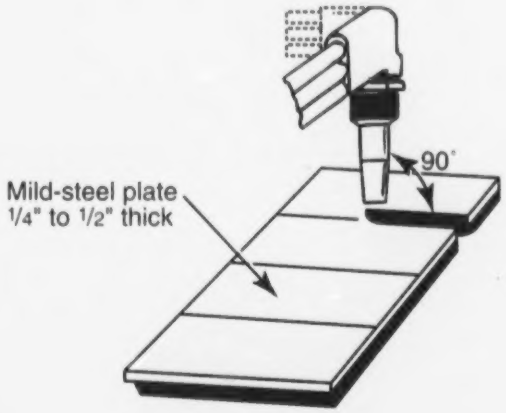
☐ k. Hold preheat flame with tip of inner cone 1/16 to 1/8 inch above top of plate at right edge until red spot appears.

> Caution: Burning metal flames and sometimes sparks, creating the danger of burns.

☐ l. Depress oxygen cutting lever and move from right to left across the plate.

Note: Left-handed operators should move from left to right.

Figure 1



- ☐ m. Hold tip at right angle to work, while cutting with inner cone approximately 1/16 inch above work.
- ☐ n. Make 90° cuts until you have developed the proper procedure.
- ☐ o. Cool metal by placing in can of water with the aid of pliers.

☐ 3. To restart a cut:

- ☐ a. Release oxygen cutting lever.
- ☐ b. Preheat only the edge where cutting action was stopped.
- ☐ c. Depress oxygen cutting lever slowly and continue cut.

☐ 4. Turn off equipment as outlined in Job Sheet 7.

☐ 5. Clean work area. Clean and put away all tools and equipment.

Evaluator's Comments: ______________________________

____

____

Objective 43

Job Sheet 10—Cut Round Stock

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Followed safety rules throughout procedure	______
• Attached cutting torch body and cutting tip correctly	______
• Marked workpiece correctly	______
• Adjusted working pressure and flame correctly	______
• Cut workpiece correctly	______

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Oxyacetylene cutting outfit with tip assembly
- Pieces of reinforcing bar, $^{1}/_{2}$-, $^{5}/_{8}$-, $^{3}/_{4}$-, or 1-inch (or other round mild steel rod
- Soapstone with a sharp point or edge
- Tape
- Welding gloves
- Welding goggles, shield, or helmet
- Protective clothing—Long sleeves and pants or coveralls
- Pliers
- Flint lighter
- Welding or cutting table
- Slag box
- Can of water
- Cutting tip
- Foam or multipurpose dry-chemical fire extinguisher
- Tip cleaners

Caution: Follow all shop safety procedures.

Procedure

☐ 1. Turn on equipment as outlined in Job Sheet 7.

☐ 2. Mark reinforcing bar at desired length.

☐ 3. Adjust oxygen and acetylene regulators.

☐ 4. Place area to be cut over slag box.

☐ 5. Clean tip before lighting torch and as often as needed.

☐ 6. Light torch with flint lighter.

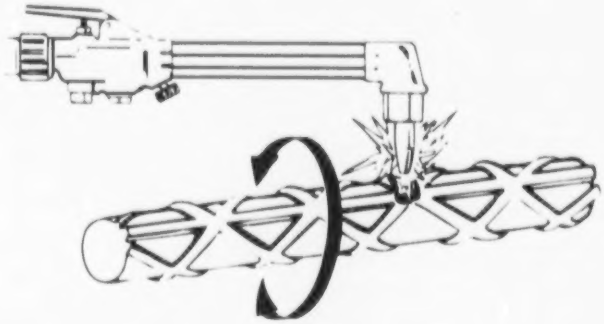
☐ 7. Adjust to neutral flame.

☐ 8. Place hoses behind you, and assume comfortable position. Maneuver torch as required.

☐ 9. Hold preheat flame with tip of inner cone 1/16" to 1/8" above edge of reinforcing bar until it becomes red.

☐ 10. Depress cutting lever, and rotate torch in direction of travel until rod is cut.

Figure 1



☐ 11. Hold tip at right angle to work, while cutting with inner cone approximately 1/16" above work.

☐ 12. Cool metal by placing in can of water with the aid of pliers.

☐ 13. Repeat procedure for each bar or rod.

☐ 14. Turn off equipment as outlined in Job Sheet 7.

☐ 15. Clean work area. Clean and put away all tools and equipment.

Evaluator's Comments: ______________________________

____

____